THE
POPULAR SCIENCE
MONTHLY

NOVEMBER, 1911

THE BERING RIVER COAL FIELD, ALASKA[1]

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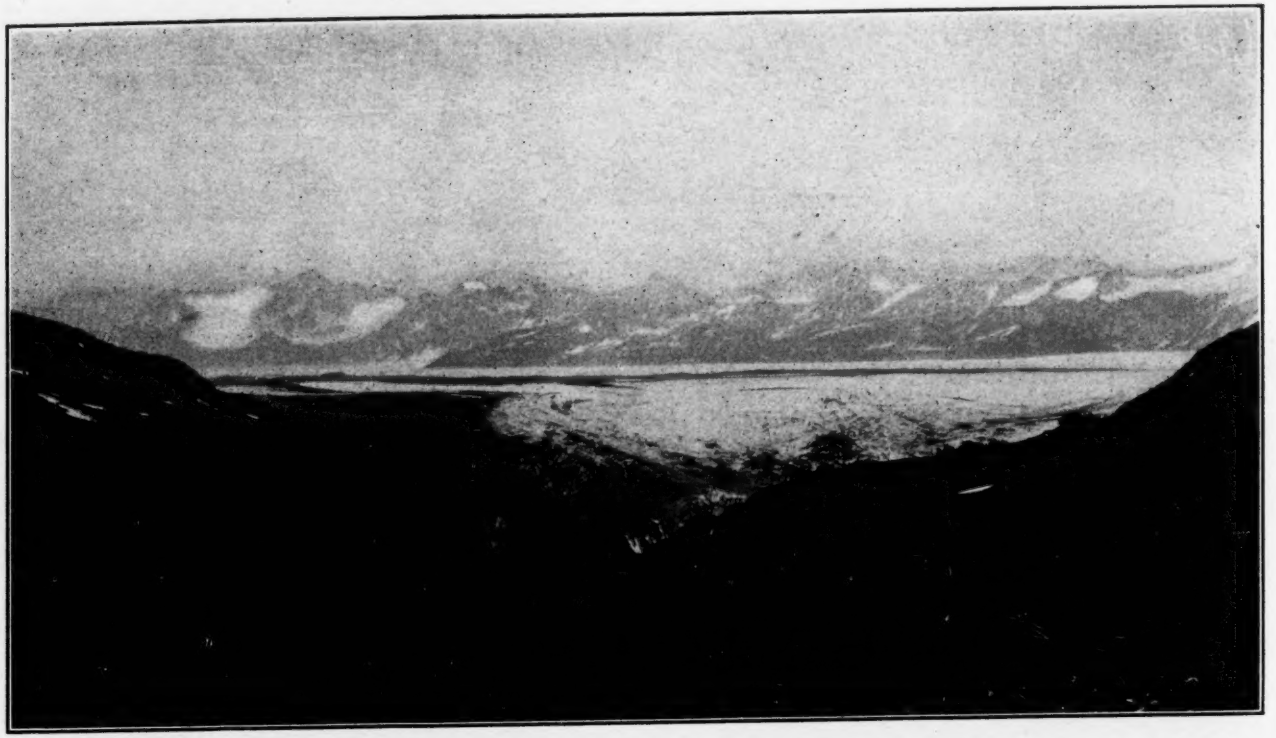
Introduction

THE Bering River coal field lies a few miles inland from the north shore of Controller Bay, an indentation of the Pacific coast about 1,200 miles from Seattle. In this field are the Cunningham claims which received much publicity in connection with the Pinchot-Ballinger controversy. Much of the coal area is within the drainage basin of the Bering River. To the north of the field is the Martin River glacier with the lofty, snow-capped Chugach range of mountains beyond; to the east of the field and extending for many miles is the Bering Piedmont glacier.

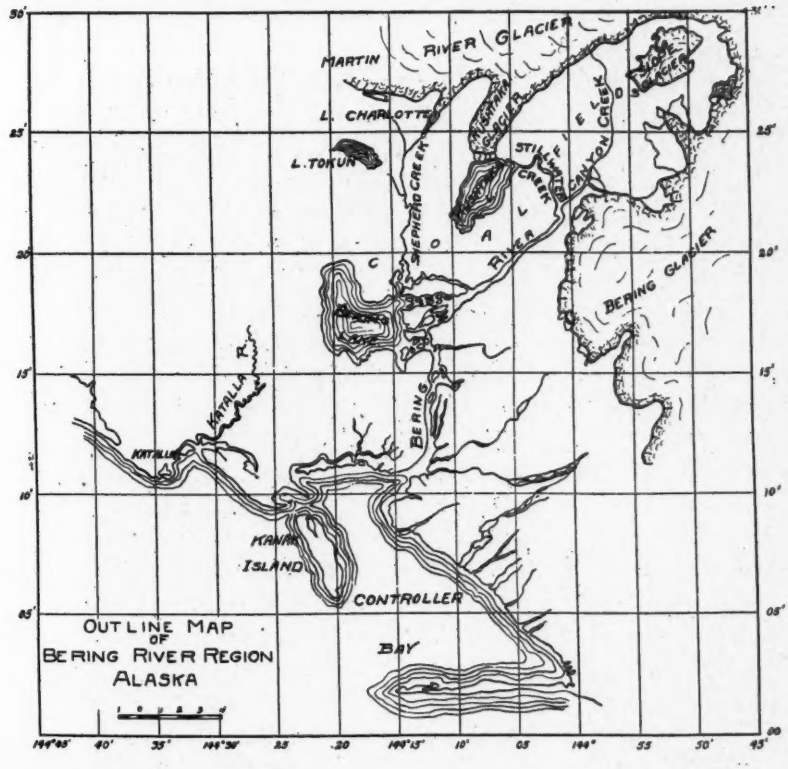
The coal field is accessible by launch and small boat from the village of Katalla, a calling port for passenger steamships. From Seattle to Katalla by way of the "inside passage" is a voyage of seven or eight days; to Cordova, by the "outside passage" and thence to Katalla is a voyage of about five days.

No railroad has yet been built into the coal field, although several surveys have been made and some construction work has been done. Until a railroad has been completed and shipment has been made possible from the coast, the field will remain undeveloped. The chief difficulty in providing transportation facilities is the lack of good harbors on Controller Bay and adjacent parts of the coast. The waters are shallow and the coast storm swept. Many thousands of dollars have already been expended in an endeavor to form sheltered harbors, but it can scarcely be said that the efforts, thus far, have been successful. However, a deep water channel extending into Controller Bay and protected by islands from the ocean storms has recently been mapped by the Coast Survey. It would seem from present evidence that when a

[1] Sometimes named the Controller Bay Field or the Katalla Field.



LOOKING INTO THE HEAD OF CANYON CREEK FROM THE HARTLINE CLAIMS.
Shows the Martin River Glacier and the Chugach Mountains.



thorough knowledge of the coast has been obtained the difficulties of securing suitable harbors will not be insurmountable.

The Copper River and Northwestern Railway Company, which has a railroad running northward into the interior from the splendid harbor of Cordova, has surveyed a branch line from this road to Katalla and thence to the coal field. The distance from the coal field to Cordova by this route is about 90 miles. Another route has been surveyed from the main line to the coal field by way of Charlotte Lake. By this route the distance to Cordova is only about 60 miles.

The area within which coal has been found extends in a southwest-northeast direction from Bering Lake to beyond Slope glacier, a distance of more than twenty miles. The width of the known coal formation is, in the northeastern part of the area, more than five miles, but the average of the field is considerably less.

The chief areas applied for in this field include the following: Controller Bay group, Pittsburgh group, Youngstown group, Cleveland group, Rathbone and Aurora groups, Pacific Coal and Oil Company group or English Company group, Cunningham group, Chezum group, Wardell group, Hartline group, Alaska Petroleum and Coal Company group, Willoughby group, the claims of the Portland Alaska

Anthracite Coal Company, the Alaska Anthracite Coal Company, the McKenzie Anthracite Coal Company, the Carbon Mountain Anthracite Coal Company and the Alaska Hard Anthracite Coal Company. Almost all the field was located prior to November, 1906, at which time these coal lands were withdrawn from entry by the government.

According to law each entry of 160 acres must have been made by an individual, or at most 640 acres by four individuals, and in the interests of the entrymen. By an act of 1906 entries made in good faith under the previous law were allowed to be consolidated into single holdings not exceeding 2,560 acres of contiguous land. Many of the claimants have done a considerable amount of development work, have had their lands surveyed, have paid in ten dollars an acre to the government, which is the requirement by law, and are now awaiting their patents.

The chief literature which has appeared on the Bering River field has been published in Bulletins of the United States Geological Survey. A complete list of the articles which have been written by members of the Survey and others may be found in the bibliography of Bulletin No. 442 of the Survey, by Dr. A. H. Brooks. Of all the published reports, that by Dr. G. C. Martin, in Bulletin No. 335, entitled "Geology and Mineral Resources of the Controller Bay Region," is the most exhaustive. Accompanying this report are very satisfactory geologic and topographic maps. In an article by George W. Evans, in the March, 1910, issue of *Mines and Minerals,* and also in an article by L. W. Storms in *Engineering and Mining Journal,* Vol. 90, p. 273, may be found maps showing the surveyed railway lines and the names and locations of the groups of claims which have been applied for in this field. A good Coast and Geodetic Survey chart of Controller Bay and adjacent parts of the coast is chart No. 8513.

The Geography of the Region

The topography of the area embraced by the known coal outcrops is rugged for a region of moderate relief. The elevations vary from a few feet above sea level at Bering Lake to somewhat more than 4,000 feet at the northeastern end of the field. The general trend of the ridges and mountains is northeast and southwest. A striking physiographic feature is the presence of broad valleys filled with alluvium and now occupied by comparatively small streams, except in times of flood. The numerous small valleys are V-shaped, often canyon like; the slopes from the divides are usually steep and broken by many gulches.

The largest stream is Bering River, which takes its rise in the lakes at the margin of Bering glacier. Its chief tributaries receive their waters from the abundant rainfall, and from the melting snows of Martin River glacier and its lobes. The tributary, Canyon Creek,

flows from beneath the margin of the glacier; Stillwater and Shepherd Creeks drain Lakes Kushtaka and Charlotte, respectively. Both of these lakes are of glacial origin.

The precipitation of the region is probably in excess of 130 inches annually. The snow fall is very heavy. Above an elevation of 1,500 feet considerable snow is present even during the summer months.

The climate is not severe, the coldest weather recorded being 2° F. above zero. The average winter temperature is about freezing point; the average summer temperature between 50° and 55° F.

A Sill of Igneous Rock in contact with a Seam of Coal. Some of the coal has been converted into coke as a result of the intrusion. South end of Carbon Mountain.

Entrance to a Tunnel on the Purdy Claim West of Shepherd Creek.

The slopes are usually timbered with spruce and hemlock to an elevation of more than 1,000 feet.

The Geology of the Region

The chief rocks of the coal field consist of indurated sediments of Tertiary age and unconsolidated stream deposits, abandoned beaches and morainal material of Quaternary age. Associated with the Ter-

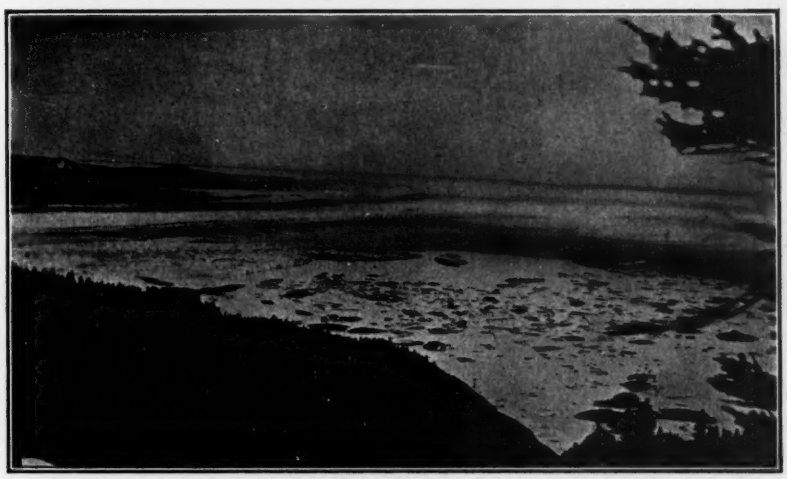
DAVIS CAMP ON CANYON CREEK. These buildings are on the claims of the Alaska Coal and Petroleum Company.

LOOKING TOWARD SLOPE GLACIER FROM THE HARTLINE CLAIMS. It shows the structure of the coal-bearing rocks in this part of the field.

tiary sediments in the northeastern part of the field are narrow dikes and sills of diabase and basalt which are either Tertiary or post-Tertiary in age. The morainal deposits extend beyond the present limits of glaciation only a few miles.

The Tertiary sediments have been divided by Dr. Martin into three formations, namely, the Stillwater, the Kushtaka and the Tokun. The Stillwater is the oldest formation, and consists chiefly of sandstone and shale with a thickness of about 1,000 feet. The Kushtaka overlies the Stillwater conformably and is that part of the Tertiary which contains the beds of coal. It has a thickness of about 2,000 feet made up of coarse arkose, sandstone, shale and beds of coal. Complete sections

PART OF THE CUNNINGHAM CLAIMS. Taken from divide west of Kushtaka Glacier.



OVERLOOKING FIRST BERG LAKE AND BERING GLACIER FROM THE GREEN CLAIMS.

of the formations are not well exposed, and hence the number of seams of coal is not well known. The evidence suggests more than a dozen seams, varying in thickness from 6 inches to more than 35 feet. The Tokun formation overlies the Kushtaka conformably and consists of about 2,500 feet, chiefly of sandy shales, but containing also, sandstone and a subordinate amount of limestone. All the evidence thus far found indicates that the Stillwater formation is marine, the Kushtaka, non-marine, and the Tokun marine.

THE STRUCTURE OF THE REGION

The structure of the rocks of the coal field is, in general, monoclinal, the most prevalent strike being northeast; the dips are usually

steep to the northwest. The main topographic features of the region have a general northeast-southwest trend, and are related in a broad way to the structure. But detailed study of small areas within the field emphasizes very clearly that the structure is much more complex than is indicated by a general study of the field. This complexity is due to folding, to faulting, and in the northeastern part of the field, to associated igneous rocks. Apart from a few well-defined lines of faulting with northeasterly and southwesterly trend, there are many small faults running in various directions. Moreover, within small areas in the field the strikes and dips are often irregular. The rocks

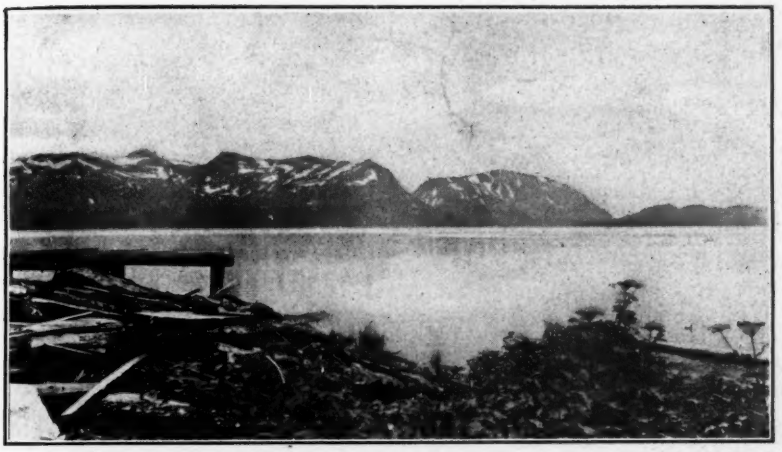
VIEW TAKEN FROM DOUGHTON PEAK, looking to the left of the ridge running northward and named Carbon Mountain. Shows structure of the coal-bearing rocks.

are frequently very much broken and jointed, and slickensided surfaces, especially in the coal, are common.

This complex structure was produced by the intense crustal movements to which the rocks were subjected during late Tertiary or post-Tertiary time. Recent subsidence of the region is indicated by the presence of alluvial deposits, in places several hundreds of feet in thickness, in the broad valleys now occupied by comparatively small streams.

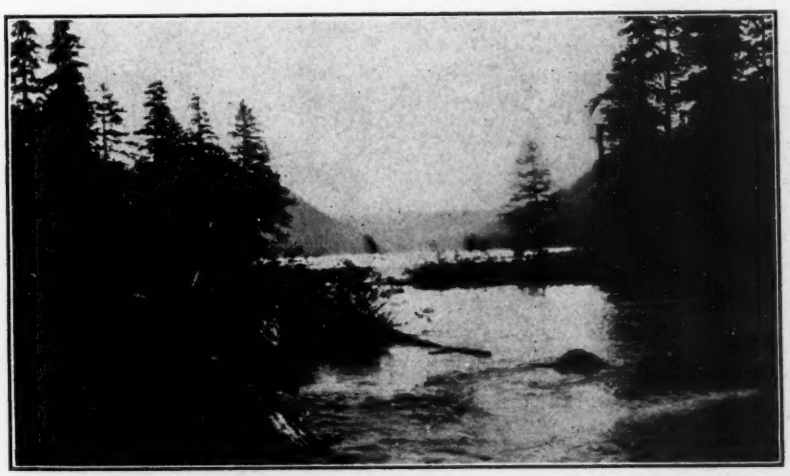
THE COAL

The coal beds are restricted to the Kushtaka formation which has a known surface area of about 50 square miles. The evidence is fairly clear that an additional area of more than 20 square miles underlies the Tokun formation at varying depths. The coal beds are distributed throughout the thickness of the Kushtaka formation. Where sections

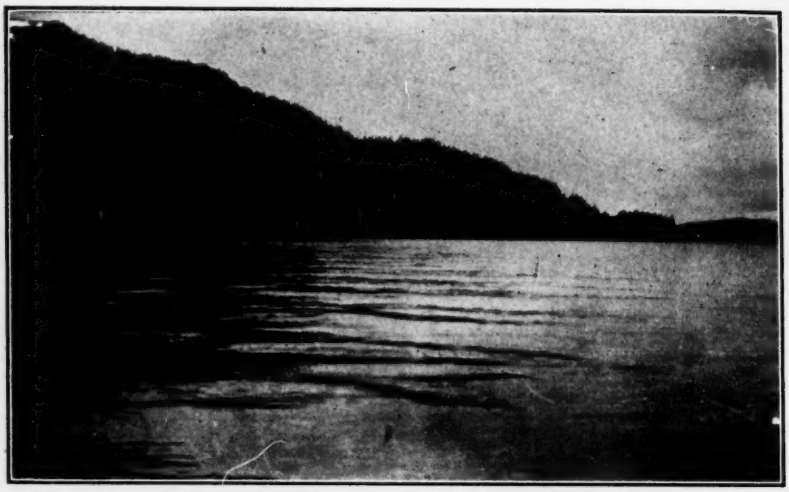


VIEW TAKEN FROM THE McDONALD CAMP ON THE EAST SHORE OF BERING LAKE, looking to the left of Katalla Valley on the opposite side of the lake.

of the formation are best exposed, more than a dozen seams of coal may be seen, but several of these are thin and unimportant. In places, the best coal beds have thicknesses of more than 25 feet of good coal; at many places beds exceeding ten feet may be seen. Owing to the complexity of structure and the small amount of development work it is impossible to correlate the coal beds in one part of the field with those of other parts, even when the outcrops are not widely separated. The thicknesses of the beds often vary greatly within short distances along both the strike and the dip. In some places the evidence suggests that the irregularities in thickness are due to movements, the coal having been squeezed into great pockets of irregular shape. More-



VIEW TAKEN FROM THE MOUTH OF CHARLOTTE LAKE, looking toward a lobe of Martin River Glacier.



POUL POINT, EXTENDING INTO BERING LAKE.

over, in some places there is a somewhat abrupt change from a bed of good coal of considerable thickness into coal of a much lower grade or into carbonaceous shale. In some places the movements have resulted in the coal being intimately mixed with the rocks of the roof and the floor. The roof and floor are most commonly of shale. One sometimes finds the roof to be of shale and the floor of sandstone, or *vice versa;* in a few places sandstone forms both the roof and the floor. The roof is frequently fractured to such an extent that in mining timbering will be necessary.

The coal of the region is of good quality, the best grade being anthracite, the poorest grade semibituminous. The average of 32 analyses of samples of coal taken by Dr. Martin so as to represent the coals of the whole field was as follows:

	Per Cent.
Total moisture	6.02
Volatile combustible	10.44
Fixed carbon	75.30
Ash	8.23
Sulphur	1.47

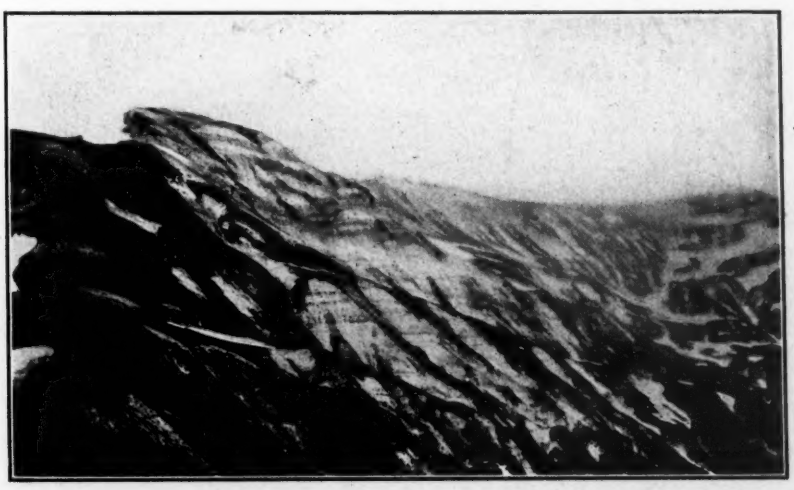
The fuel ratios of these coals varied from 3.61 to 15.88, the average being 7.78. The highest B.T.U. value was 15,574, the lowest 8,386 and the average of the 32 analyses was 13,174. The average analysis of 7 of the coals which were classed as anthracite was

	Per Cent.
Moisture	7.88
Volatile combustible	6.15
Fixed carbon	78.23
Ash	7.74
Sulphur	1.30

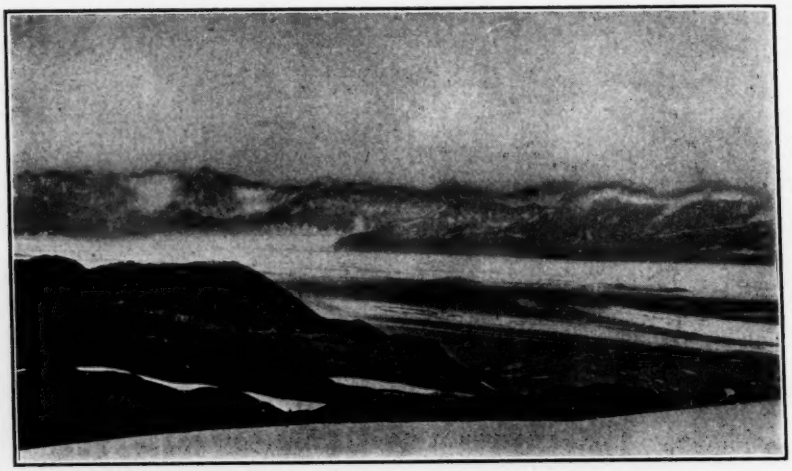
The semibituminous grade of coal is found in the southwestern part of the field, the anthracite in the northeastern. Between these two areas the grade of coal is intermediate between semibituminous and anthracite. The distribution of the grades of coal corresponds somewhat closely to the complexity of structure in the different parts of the field. The structure becomes more and more complex from the southwest toward the northeast. The grade of the coal has been made better with an accompanying complexity of structure.

The semibituminous coal has been shown to possess good coking properties.

A striking feature of the coals, and one which is likely to be a serious handicap to their utilization, is their crushed and sheared condition. In many of the surface exposures and in the tunnels, drifts and open cuts where development has been carried on, the coal is soft and friable. Even where fairly firm and unbroken masses of coal are found, they can be readily crushed. It is difficult to find large lumps of coal free from fractures and slickensided surfaces. During mining, such coal can not escape being badly broken, and the difficulties of shipping will be great. In the case of the anthracite, the crushed and friable condition is likely to seriously impair its market value. With regard to the grades of coal of coking quality the soft character may not be so serious in that the coal can be converted into coke before shipping. It is scarcely probable, in a region where the crustal movements have been so widespread and intense, that the coals below the zone of surface disintegration will be free from the crushed and fractured conditions so prevalent at and near the surface.



FROM DOUGHTON PEAK LOOKING NORTHWARD TO THE RIGHT OF CARBON MOUNTAIN. Shows the structure of the coal-bearing rocks.

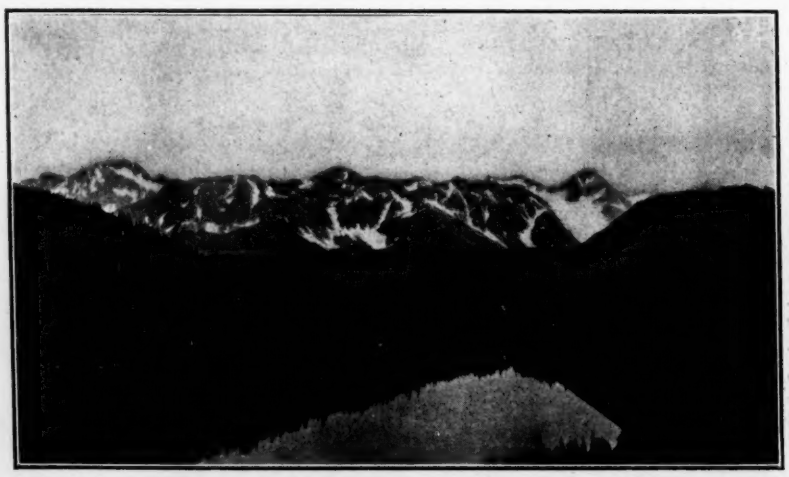


VIEW FROM CHEZUM GROUP, WEST OF CANYON CREEK, looking over Martin River Glacier to the Chugach Mountains beyond.

Gas has been found in several of the tunnels; hence, in mining, safety devices will be necessary.

DEVELOPMENT

At more than 300 places within the field more or less development work has been done. But no extensive mining has been carried on. The most prevalent kind of work consists of small surface openings. However, more than 30 drifts or tunnels have been run with an aggregate length of more than 3,000 feet. The most systematic development work has been done on the Cunningham, the Controller Bay, the Eng-



VIEW FROM THE ENGLISH COMPANY CLAIMS, looking over Lake Charlotte to the mountains beyond.

lish Company, and the Davis groups. On the Cunningham claims several long tunnels have been run. At the McDonald mine on the Controller Bay group is a working drift more than 600 feet long. On the claims of the English Company there are three tunnels with a total length of more than 900 feet. On the Davis group is a tunnel whose length is more than 500 feet. During the summer of 1910 the Davis group was the only one in the field upon which systematic development work was being carried on.

LOOKING DOWN ELK CREEK, HARTLINE CLAIMS.

SUMMARY AND CONCLUSIONS

The coals of the Bering River field are of good quality, and the tonnage is unquestionably great. But the probable amount of this coal which is available at present or will be available in the near future can not be stated with any degree of reliability. The conditions of occurrence are such that until extensive development has revealed many data at present unknown, an estimate of the available coal would be little more than a guess. In coal fields of somewhat simple structure fairly reliable estimates may be made of the available coal from a study of the outcrops, but in fields such as the Bering field, where the structure is complex, such estimates are of little value, and in fact may be harmful. The figures are likely to be overemphasized, and even misused, by those who are endeavoring to interest the investing public. In much of the Bering field the rocks are folded, faulted, jointed and crushed; the coal beds are known to vary much in thickness within short distances along both the strike and the dip; the coal beds in several places may be seen to change somewhat abruptly into carbonaceous shale, and in places they are intruded by igneous rocks. As yet, the beds in the different parts of the field have not been correlated, nor is

it possible to state the number of beds which are workable. Moreover, when it is recalled that gas is present in the coals, that the region is one of abundant rainfall, that the snowfall is heavy, that the coals are in many places friable, that many difficulties and large expenditures are connected with the problem of railroad construction and the providing of docking facilities, one begins to realize how necessary it is to give full weight to these facts in reaching a conclusion as to the value of the field.

The opening up of this field would be a great boon to Alaska and to the states of the Pacific coast. The government should do all in its power to hasten development. In cases where the evidence shows that the entrymen have conformed to the law, the patents should be issued without delay. Moreover, the Alaskan coal land laws should be speedily revised. The existing laws are unsatisfactory in that they do not tend to encourage but rather to discourage development. Not until large sums of money have been invested in this field will it be possible to mine and ship the coal on a commercial scale.

INSECT PARASITISM AND ITS PECULIARITIES[1]

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IT is universally admitted that economic entomology, like such other branches of applied biology as medicine and sanitary science, is to a very considerable extent the strategics of our warfare with a host of parasites, which are forever endeavoring to destroy our bodies, our domestic animals, our food supply, our clothing and the very materials with which we construct our dwellings and on which we write or print our interpretations of the wonderful world in which we live. In other words, economic entomology is, to nearly all intents and purposes, merely that portion of applied parasitology which deals with insects. Naturally, therefore, the destruction of the insect parasites of man and of the plants and animals on which his very existence depends, must always constitute the basic interest of this science.

A vague notion of putting certain of the parasites themselves to some use in the struggle to which I have referred, seems to have been apprehended even in pre-scientific times and among primitive peoples. We have read of savage tribes, which, like monkeys, eat their hexapod ectoparasites. The Aztecs invented another use for these creatures, as we learn from a quaint work published many years ago by Cowan.[2] He cites the following story from Torquemada "respecting the revenue of Montecusuma which consisted of the natural products of the country, and what was produced by the industry of his subjects. During the abode of Montecusuma among the Spaniards, in the palace of his father, Alonzo de Ojeda one day espied in a certain apartment of the building a number of small bags tied up. He imagined at first that they were filled with gold dust, but on opening one of them, what was his astonishment to find it quite full of lice? Ojeda, greatly surprised at the discovery he had made, immediately communicated what he had seen to Cortes, who then asked Marina and Anguilar for some explanation. They informed him that the Mexicans had such a sense of their duty to pay tribute to their monarch that the poorest and meanest of the inhabitants if they possessed nothing better to present to their king, daily cleaned their persons, and saved all the lice they

[1] A lecture delivered at the Marine Biological Laboratory, Woods Hole, Mass., August 8, 1911. In preparing the lecture for publication several footnotes have been added and the concluding paragraphs have been rewritten.

[2] "Curious Facts in the History of Insects," J. B. Lippincott & Co., Philadelphia, 1865.

caught, and that when they had a good store of these, they laid them in bags at the feet of their monarch." A more scholarly, not to say more spiritual, use of parasites, seems to have been invented by no less a personage than the founder of the Dominican order of monks, since it is related in the same work "that the Devil, teasing St. Domingo in the shape of a flea, skipped upon his book, when the saint fixed him as a mark where he left off, and continued to use him so through the volume."

Although we may infer from such personal and therefore very trivial uses of fleas and lice as food, book-marks and taxes, that both saints and savages have occasionally endeavored to make their parasites subserve a useful purpose, it is only within very recent times that what may be properly called an *economic* use has been suggested for certain parasitic and predatory insects; namely, that of controlling the insects injurious to our crops, forests, domestic animals, stored foods and fabrics. The notion of using predatory beetles in destroying garden pests seems first to have occurred to Boigiraud de Poitiers in France in 1843 and in the following year to Antonio Villa in Italy.[3] The latter country also produced the two entomologists Rondani and Ghiliani, who, during the fifties and sixties of the past century, first suggested the use of parasitic insects for similar purposes. Since 1870 this suggestion has taken firmer hold of entomologists, especially in France, Italy and the United States, largely owing to the remarkable results achieved by Riley, Howard and their collaborators in our federal Bureau of Entomology. To mention only a single example, it has been found that the fluted scale (*Icerya purchasi*), so destructive to the orange, can be controlled by an Australian ladybird (*Novius cardinalis*), and this control has been successful in California, New Zealand, Cape Colony, Hawaii, Florida, Portugal, Italy, Syria and Egypt. The scale was accidentally introduced into all of these countries and in all of them the beetle, when in turn introduced, showed itself capable of preventing the pest from spreading and destroying the orange trees. This and many similar, though perhaps less striking, cases, have led entomologists to ransack remote regions of the globe for parasites to rear and turn loose on the noxious insects, which, after accidental introduction into our country, increase so alarmingly and do so much damage, owing, in great measure at least, to the absence of the parasites and other enemies that keep them in check in their native environment. The most elaborate experiment of this nature and one which is being followed with keen interest by all economic entomologists, is now being carried on at the Parasitological Laboratory at North Melrose, near

[3] For a fuller account of the work of these and other early promulgators of the use of predators and parasites in combating noxious insects, see Trotter, "Due precursori nell' applicazione degli insetti carnivori a difesa delle piante coltivate," *Redia*, V., 1907, pp. 126–132.

Boston. Here for several years past great numbers of parasites have been received from Europe and northern Asia, carefully reared and studied, and, when found to be sufficiently promising, liberated in the hope that they will multiply and eventually control the gypsy and brown-tail moths.[4]

The fact that such economic uses have been suggested for insect and not for any other parasites seems to imply that the former must be peculiar in certain important particulars. This I believe to be true and has led to the following considerations. That I have chosen to read them to you, who are primarily interested in the problems of zoology in its broadest sense, is due to a conviction on my part that many of the accounts of parasitism, even in the best of our zoological hand-books, are more or less one-sided and anthropomorphic, probably as a result of the stepmotherly treatment necessarily bestowed upon the insects in such treatises. Before I say more about the insects, however, I wish to make a few remarks on animal parasitism in general.

Parasitism is, of course, a form of "behavior," and may be described as one of several complex types of the reactions of organisms to the most important source of their energy, their food supply. Other reactions to this element of the environment are predatism, commensalism, scavengerism and mutualism. There is in the main sufficient consensus of opinion concerning the distinctions between these different phenomena. Predatory animals kill other animals and devour them wholly or in part. Parasites put other organisms in the position of "hosts" by living *directly* on their tissues in such a manner as not to cause their immediate death. The parasite thus draws *indirectly* on the food supply of another organism by permitting or compelling it to do the hard work of procuring the food and of converting it into much more accessible and much more easily assimilable compounds. The parasite may be said, therefore, to use its host as an instrument not only for procuring, but for predigesting, its food. The commensal also uses another animal as an instrument, but merely in gaining access to a food-supply which the latter has procured but has not yet assimilated. The scavenger, like the saprophyte among plants, may be described as a parasite of the dead, deriving its sustenance from decom-

[4] Excellent general accounts of the subject here touched upon are contained in the following papers: Marchal, "Utilization des Insects Auxiliaires Entomophages dans la Lutte contre les Insects Nuisibles a l'Agriculture," *Ann. de l'Inst. Nat. Agronom.* (2), VI., 2, 1907, 74 pp., 26 figs.; translation in part in POP. SCI. MONTHLY, LXXII., 1908, pp. 352–370, 406–419; Silvestri, "Sguardo allo Stato Attuale dell' Entomologia Agraria negli Stati-Uniti del Nord America, etc.," *Boll. Soc. Agric. Ital.*, XIV., No. 8, 1909, 65 pp.; Howard and Fiske, "The Importation into the United States of the Parasites of the Gypsy Moth and the Brown-tail Moth," Bull. No. 91, Bur. of Ent., Dep. Agric., 1911, 312 pp., 73 figs., 25 pls.

posing animals or plants or from the excretions of the former. The mutualist, finally, as the name implies, lives in a condition of balanced energetic or nutritional cooperation with another organism.

Of all these types of reactions to the food supply, parasitism is far and away the most prevalent; so prevalent, in fact, that it may be doubted whether there is any animal that does not resort to it, at least during a brief portion of its life, even if this be only during the period when, as an egg, it is drawing its supply of food-yolk from its parent. That parasitism has been most frequently developed from predatism is certain, that it may occasionally have its origin in commensalism, mutualism or scavengerism is highly probable, that it can, especially when it affects a considerable portion of the life-cycle of an organism, develop into anything but a more extreme form of parasitism, is very doubtful.

It would be easy to show by the citation of many examples that parasitism is an extremely protean phenomenon, one which escapes through the meshes of any net of scholastic definitions in which we may endeavor to confine it. Nor is this surprising when we stop to consider its great prevalence and the fact that during the course of time the organic world, *pari passu* with its increasing differentiation, has become ever more and more heavily weighted with parasitism and mutualism. That this nutritive dependence of organisms on one another has been steadily growing during paleontological time is clearly seen in the comparatively recent development of viviparity in mammals and many other animals, in the development of the alternating generations of plants into a condition in which the gametophyte is parasitic on the sporophyte (gymnosperms and angiosperms) or the sporophyte on the gametophyte (ferns and mosses), in the increasing mutualistic relations between insects and angiosperms, in the enormous development of parasitism among the highest orders of insects, the Diptera, Hymenoptera, Coleoptera, Lepidoptera and Homoptera, which are not known to have existed before Jurassic and Triassic times, and even in many apparently more primitive parasites like the true lice, bird lice, bat lice, fleas and many tape worms, flukes and round worms, which could not have developed till after their mammalian and avian hosts had made their appearance. Social life, too, which is hardly more than a mixture of parasitism and mutualism, shows a similarly recent development. Man himself, with whom we do not commonly associate the idea of parasitism, although the term is derived from a certain type of man well known to the ancient Greeks, not infrequently displays an extraordinary variety of parasitic activities. As an embryo he is always entoparasitic, using his allantois in a manner that vividly suggests the root-system of a *Sacculina* attached to a crab. At birth he becomes a kind of ectoparasite on his mother or nurse, and throughout his childhood and youth he is commonly what might be called a family parasite, de-

pending for his sustenance on his parents, brothers and sisters or remoter relations. At maturity, in addition to the possibility of becoming parasitic on his wife, he has a choice of many kinds of social parasitism. As a member of a trust, political party or legislative body, not to mention many other organizations and institutions, he may graft successfully on the community at large or on some particularly lucrative portion of it, and should he fail through these activities to store up a sufficient *corpus adiposum* in the form of a bank-account, he may parasitize, with advancing years and till the end of his days, on his own offspring.[5]

But the roots of parasitism may be traced even deeper within the very fabric of the organism itself. The theories of Roux and Weismann have made us familiar with the struggle among the parts of the individual organisms, *i. e.*, among its organs, tissues, cells and the components of its cells, a struggle in which these elements often grow and develop at the expense of other elements in a manner that can only be regarded as parasitic. The more modern theories of mutation and Mendelism, with their insistence on unit-characters and "factors," obviously admit of an interpretation in similar terms. We can even shift this interpretation to the psychic plane, where we find the fixed ideas, obsessions and monomanias behaving as so many processes which draw their sustenance from other psychic processes to such an extent that they may in the end not only dominate but destroy the whole personality.

Some of you will be shocked at this account of what we are in the habit of describing in very different language, for the same emotional reason that we all admire the tiger and the tiger-beetle and loathe the tape-worm and the louse, namely, because our instinctive horror of the parasites to which our species is so constantly exposed, prevents us even as twentieth-century zoologists from appreciating the extent to which all life, ourselves included, is saturated with parasitic proclivities. I fear, however, that this attempt to justify my shocking language will fail to convince some others among you, who will accuse me of being myself a host of one of the obsessions to which I have just alluded—of the parasitic obsession, namely, of the idea of parasitism. You will say that in thus subtilizing or volatilizing what has always seemed to be a concrete biological phenomenon, and in thus diffusing the concept

[5] Certain general aspects of social parasitism in man are admirably presented by Massart and Vandervelde in their work entitled "Parasitisme Organique et Parasitisme Social," *Bull. Sci. de France et de la Belg.*, XXV., 1893, 68 pp., and by Ross in Chapter XXVIII. of his "Social Control," Macmillan Co., New York, 1910. The conception of viviparity as a form of parasitism has been developed by Giard ("Sur la signification générale du parasitisme placentaire," *C. R. Soc. Biolog.*, 1897), Houssay ("La Forme et la Vie. Essai de la Methode Mécanique en Zoologie," Paris, 1900) and Faussek ("Viviparity and Parasitism," in Russian, *Russkoje Bogatswo*, 1893).

of parasitism over the whole organic world, I have not only distorted it beyond recognition, but have deprived it of any usefulness which it may have had. To such accusations I can only reply that I gladly concede that it is admissible for practical purposes to circumscribe parasitism by arbitrary names and definitions in special fields of biological, sociological and psychological study, but I must insist, nevertheless, that it is a very fundamental and far-reaching phenomenon, which, for theoretic and heuristic purposes, may properly be said to include any complex of vital processes, which maintain themselves at the expense of other vital processes, in the same or in other organisms, without reacting on these processes in a similarly sustentative manner. But let us return to the more conventional conception of the subject.

When an organism becomes parasitic it, of course, undergoes structural and physiological changes. These express themselves in the loss or modification of previously existing characters and in the acquisition of new characters. The amount of this loss, modification and acquisition depends, first, on the intimacy of relationship of the parasite to the host; second, on the nature of this relationship; third, on the time in the parasite's ontogeny when this relationship is established, and fourth, on the portion of the ontogeny which it covers. Ectoparasites, as we all know, are, as a rule, less modified than entoparasites, but each of these categories includes very different degrees of modification, according as the parasite is confined to a particular organ of the host or is capable of moving more freely over its surface or through its tissues. The habitus of a parasite is most profoundly influenced and characterized by the moment in its ontogeny when it joins its host, and especially by the length of the period during which this association is maintained. According as this association is coextensive with the parasite's life or merely for a briefer period, we may distinguish *permanent* and *temporary* parasites. The latter, again, may be divided into those that are free from their hosts only during larval or early life and those that are free as adults. To these three types practically all animal parasites can be referred. They are best represented by such forms as certain tape-worms and flukes, by such crustaceans as *Sacculina,* and by such insects as the Ichneumonidæ and Chalcididæ among Hymenoptera and the Tachinidæ among Diptera. Permit me to describe very briefly the salient peculiarities of a typical example of each of these groups.

The tape-worm is an excellent example of a permanent parasite. It produces an enormous number of very minute eggs, and either these or the singular embryos, known as onchospheres, which they contain, are passively swallowed by the host. The onchosphere passes from the alimentary tract into the tissues of the host and there becomes a bladder-worm. This, in order to become a sexually mature tape-worm, must enter the alimentary tract of a second host. The transfer is effected

passively by the second, or definitive, devouring the first, or intermediate host. Both stages of the parasite exhibit extreme modification of structure, the second being characterized by an enormous development of the hermaphroditic gonads and of the alimentary surface, which is merely the integument, and is therefore in immediate contact with the food supply. To this type of parasitism we may also refer the Dicyemids, and many of the flukes and round-worms. In many of these cases the association with the host may be effected without any effort on the part of the parasite, and the small size, the enormous number and the method of distribution of its eggs are properly interpreted as so many direct and necessary adaptations to chance.

The Rhizocephalous crustacean *Sacculina,* which may serve as a paradigm of the second type, or that of temporary parasitism with free early ontogenetic stages, also produces an enormous number of minute eggs. These, however, develop into free-swimming Nauplii, which in turn become Cypris larvæ and as such seek out their Decapod or Isopod hosts. Owing to the activity and comparatively high organization of these larvæ, the element of chance in bringing about the host association, though still considerable, is not as great as it is in the tape-worm. When it has joined its host, the Cypris larva, through one of the most remarkable methods of development known to exist among animals, proceeds to undergo structural modifications so extreme that, without a knowledge of the earlier stages, the crustacean affinities of the organism would never be suspected. "In the adult state the body consists of two portions: a soft bag-like structure, external to the host, carrying the reproductive, nervous and muscular organs and attached to some part of the host's abdomen by means of a chitinous ring; and a system of branching roots inside the host's body, which spring from the ring of attachment and supply the external body with nutriment."[6] In *Sacculina,* as in the tape-worm, the gonads are hermaphroditic and reproduction takes place by a continual round of self-fertilization. To this type of temporary parasitism with free larval stage we may also refer the myzostomes and other parasitic annelids and the parasitic mollusks. In all these cases metamorphosis supervenes while the animal is still very small and hence *precedes* growth and the incidence of the modifications produced by the parasitic habit.

As an example of the third type or that of temporary parasitism with free adult stage, we may select the Ichneumonid Hymenopteron. The eggs are few in number and rather large and are deposited by the mother directly in or on the host, which is the larva of some other insect. The sluggish, bag-shaped parasitic larva, on hatching from the egg, feeds for some time on the blood-tissues and fat-body of the host, but is careful not to prevent the latter from moving about, procuring its food and growing to maturity. When it has reached this stage, how-

[6] Geoffrey Smith in the Cambridge Natural History, Vol. IV., p. 95.

ever, the parasite quickly destroys it by consuming its vital tissues. It then completes its own growth, pupates and eventually emerges as a very active, highly organized and beautifully colored fly, provided with a splendid nervous system, exquisite sense-organs and powerful locomotor organs in the shape of legs and wings. It is either a male or a female and, if of the latter sex, soon proceeds to place its offspring in immediate contact with the host. Although the larval *Ichneumon* exhibits modifications of structure almost as extreme as those of the adult *Sacculina,* these produce no effect on the organization of the adult insect. The association of the larva with its host is the work of the mother insect, a creature gifted with complex instincts that enable her to ferret out the host even in the most intricate concealment. The large size and small number of her eggs and her highly specialized method of oviposition indicate very clearly that chance, which plays such a rôle in the life-cycle of the tape-worm and *Sacculina,* has given way to an almost inevitable association of the parasite with its host.

Of course, the *Ichneumon* represents only one of many forms of parasitism among insects. I have chosen it because it is the most characteristic and most highly specialized. There are insects like the Strepsiptera and the Rhipiphorid and Meloid beetles which seem to combine the *Sacculina* with the *Ichneumon* type in that they produce many small eggs that hatch as very active triungulin larvæ and only later develop into legless, bag-like larvæ of the *Ichneumon* type. It is interesting to note that in the Strepsiptera the adult female prolongs the parasitic habit of the larva, while the adult Meloidæ or oil-beetles are rather sluggish and seem to show other after-effects of their larval life. There are also many insects, like the true lice and bird lice which are, to all intents and purposes, permanent parasites comparable with the ectoparasitic flukes, though they never exhibit such extreme modifications. And, finally, there are other animals besides insects that have parasitic larval and free adult stages, *e. g.,* the fresh-water mussels.[7]

Zoologists have naturally been deeply impressed by such wonderful parasites as the tape-worms, flukes and *Sacculina* and have regarded these as fine examples of degeneration or degradation. Many, indeed, have dwelt on these words in a manner which leaves no doubt that they are used in a purely anthropomorphic sense as implying deterioration or "an impairment of natural or proper qualities" in the parasites, notwithstanding Ray Lankester's assertion that "degeneration may be defined as a gradual change of the structure in which the organism becomes adapted to less varied and less complex conditions of life."[8] It is easy to trace the source of this anthropomorphism to the atrophy of the parasite's neuro-muscular system, a system by which we as intel-

[7] *Cf.* Lefevre and Curtis, "Reproduction and Parasitism in the Unionidæ," *Journ. Exper. Zool.,* IX., No. 1, 1910, pp. 79–115, 5 pls.

[8] "Degeneration," p. 32.

lectual beings necessarily set great store, and the hypertrophy of the alimentary and reproductive organs, which, notwithstanding their immense biological significance, have nevertheless been assigned a very inferior place in our scheme of ethical values. But parasites may properly be regarded as more advanced organisms than the predators, for they have not only had a more eventful phylogenetic career, but, during their long history, have learned to use other organisms in a very economical manner as instruments of nutrition. From a consistent biological point of view, therefore, and from one embracing insect as well as vermian and crustacean parasites, it is evident that the peculiar convergent complexions of these organisms should be attributed to *specialization.* "Degeneration" is properly a pathological term, and parasites, however pathogenic they may be, are, of course, no more pathological or diseased than predatory animals. There is some evidence to show that the myzostomes have persisted in their modern form since Silurian times, with a conservatism equalled only by that of their Crinoid hosts. If all the generations of these peculiar annelids have been pathological for millions of years, they should long since have disappeared from the waters of the globe, but we find that though many or all of the original species have doubtless become extinct, this was probably due simply to the extinction of their hosts, for nearly every extant species of Crinoid supports at least one species of *Myzostoma.* Moreover, if we regard parasitic modification as an expression of degeneration, we must suppose that such forms as the adult *Ichneumon* are produced by a post-larval regeneration. Apart from adding an unusual meaning to the word "regeneration," this fails to express the actual conditions correctly. The whole ontogeny of such insects is in reality very highly specialized, the adult representing in many particulars as great a departure from the primitive insect type as the larva, albeit in a very different direction. In discussions of this subject I would therefore substitute the words "parasitic specialization" for such terms as "degeneration" and "degradation." Together with these, another term, "retrogression," should be avoided, for the reason that the parasitic modifications of structure to which it is often applied can be more properly attributed to "arrest of development."

It will be seen from the foregoing discussion that the leading peculiarity of insect parasitism, at least in such groups as the Hymenoptera and Diptera, which are almost the only ones of value in controlling noxious insects, is *the restriction of the parasitic habit to the sluggish larva and the specialization of the free adult for the purpose of disseminating the species and of placing the coming generation in intimate contact with the host.* No one who observes one of our large, graceful Ichneumonids, such as *Thalessa lunator,* alighting on a tree-trunk and then conveying its greatly attenuated eggs by means of its long hair-like ovipositor through some three inches of hard wood into

the burrow of a *Tremex* larva, the presence of which it has been able to detect by means of its marvelously acute sense-organs, can fail to appreciate the advantages of such a method of bringing a parasite to its host, rather than by the tape-worm's shot-gun method of scattering minute eggs about promiscuously, or by the *Sacculina's* almost equally haphazard method of employing minute, feeble, aquatic larvæ.

Another peculiarity of economic importance in the parasitism of Hymenopterous and Dipterous insects is its *highly predatory character,* for the voracious larvæ of these orders almost invariably kill their hosts.[9] Other forms, like the Strepsiptera, which permit their hosts to reach the adult stage, nevertheless destroy their gonads and thus decrease the reproductivity of the host species. In some cases, indeed, it is impossible to decide whether we are dealing with parasitism or predatism. The *Sphex,* that lays her eggs on caterpillars which she has carefully paralyzed, is commonly regarded as a predatory insect, but she is from another point of view, an even more specialized parasite than the *Ichneumon.* Her sting immobilizes but does not kill the active full-grown or nearly full-grown caterpillars, and her larvæ are careful to feed in such a manner as to spare as long as possible the life of their victims. We have here merely a further extension of the maternal instincts primarily devoted exclusively to bringing about the union of the parasite with the host, to a unique and effective preparation of the host's body for easier exploitation by the parasite.

A third peculiarity of economic importance in the Hymenopterous and Dipterous insects is their *pronounced tendency to confine their attacks to species of large, recently developed and eminently noxious groups,* such as the Lepidoptera, Coleoptera, Homoptera and other plant-destroying insects.

There are also a number of peculiarities some of which are of less practical but of no less theoretical interest. These, which I must consider very briefly in the limited space at my disposal, are the following:

1. The occurrence of *hypermetamorphosis* which is frequently exhibited by parasitic insects often of the most remote taxonomic affinities, such as the Proctotrypids, and certain Chalcidids (*Orasema* and *Perilampus*) among the Hymenoptera, *Mantispa* among the Neuroptera, the whole order of Strepsiptera, and the Meloidæ and Rhipiphoridæ among Coleoptera. The complication of development arises in all of these cases from an inability of the mother insect to find the host or at any rate to reach it during the proper ontogenetic stage, and

[9] It would seem that the death of the insect host is necessitated either by the relatively very large size of its insect parasite at maturity, when acting alone, or (in cases of polyembryony and simultaneous infestation by several individuals of the same species) to the equally considerable bulk of a number of small parasites acting together. The comparatively slight difference in stature between host and parasite is certainly one of the most remarkable peculiarities of insect parasitism.

hence from the need of an active and inquisitive first larval stage to supply this defect.

2. The prevalence of *hyperparasitism.* We may distinguish primary, secondary, tertiary, quaternary and even quinary parasites among insects, according to the principle of the "little fleas *ad infinitum.*" The numerical appellations in this series have been restricted to insects parasitic on other insects, although the primary parasites are really secondaries when they attack insects like caterpillars, since these are, of course, plant-parasites.[10]

3. The absence in parasitic insects of *hermaphroditism,* a phenomenon so prevalent among vermian, crustacean and annelidan parasites. Only one small group of insects is known to be hermaphroditic, namely, the Termitoxeniidæ, comprising a few genera of extraordinary flies that live in termite nests.[11]

4. The rare occurrence of *heterœcism,* or change of host, a phenomenon very prevalent among tapeworms and flukes. It has been developed, however, within apparently very recent times in such groups as the plant-lice and in certain myrmecophilous beetles of the genera *Atemeles* in Eurasia and *Xenodusa* in North America.

5. The increasing development of *viviparity* as seen in such a series of parasites as *Hemimerus,* which, according to Hansen and Heymons, develops within the ovary of its mother,[12] the larviparous Tachinidæ and Sarcophagidæ, the nymphiparous Hippoboscidæ, Nycteribidæ and plant-lice, and the Termitoxeniidæ which, according to Wasmann, are born practically as adult insects.[13]

6. The development of *polyembryony* among the Chalcidid and Proctotrypid Hymenoptera. Owing to the greatly increased reproductivity of these parasites through the formation of dozens or even hun-

[10] Fiske ("Superparasitism: An Important Factor in the Natural Control of Insects," *Journ. Econ. Ent.*, III., 1910, pp. 88–97) and Pierce ("On Some Phases of Parasitism Displayed by Insect Enemies of Weevils," *ibid.*, III., 1910, pp. 451–458) have distinguished between "hyperparasitism" and "superparasitism." The former term is defined by Pierce as "the normal attack of a parasite species upon another parasite species," whereas superparasitism "occurs when a normally primary parasite attacks a host already parasitized, and the result is that the latest comer generally attacks its predecessor." The distinction is important, but for the sake of brevity I have not introduced into the text.

[11] Wasmann, "Termitoxenia, ein neues flugelloses, physogastres Dipterengenus aus Termitennestern," 2 Pts., *Zeitschr. f. wiss. Zool.*, LXVII., 4, 1900, pp. 559–617, LXX., 2, 1901, pp. 289–298, and Assmuth, "Termitoxenia Assmuthi Wasm.; Anatomisch-histologische Untersuchung," Inaug. Dissert., 1910, 53 pp.

[12] *Cf.* Hansen, "On the Structure and Habits of *Hemimerus talpoides* Walk.," *Entom. Tijdskr. Arg.*, XV., 1894, and Heymons, "Eine Plazenta bei einem Insekt (*Hemimerus*)," *Verh. deutsch. zool. Gesellsch.*, 1909, pp. 97–107, 3 figs.

[13] *Loc. citato.*

dreds of adults from a single original egg by a process not unlike that employed in the egg-shaking experiments of our laboratories, this phenomenon, though restricted to comparatively few species, is nevertheless of considerable economic importance.[14]

7. The development of *social life* among insects. This, as I have shown on former occasions, has its origin both ontogenetically and phylogenetically in the parasitism of the offspring on the parent.[15]

Paleontology seems to show very clearly the conditions that have favored the enormous development of parasitism among insects especially within comparatively recent times. Some of these conditions are:

1. The *diminution in insect stature* which occurred in the late Carboniferous and during the Permian and seems to have been originally in great part an adaptation to increased reproduction and dispersal. Other things equal, a small animal will, for very obvious reasons, become a parasite more easily than a large one.

2. The *development of metamorphosis.* This was already clearly established in the earliest known insects, the Paleodictyoptera, which were predatory and amphibiotic like the may-flies of the present-day, living in the water during their apterous larval stages and spending their winged imaginal stage in the air. They show plainly the great peculiarity of insect development, *i. e.,* metamorphosis *succeeding* growth and not *preceding* it as in the crustaceans, mollusks and anne-

[14] The occurrence of polyembryony was first clearly recognized and thoroughly investigated by Marchal in *Eucyrtus fuscicollis* ("Recherches sur la Biologie et le développement des Hyménoptères Parasites. I. La Polyembryonie Spécifique on Germinogonie," *Arch. Zool. Expér. Gén.* (4), II., 1904, pp. 257–335, 5 pls., and an earlier paper: "La dissociation de l'oeuf en un grand nombre d'individus distincts chez l'Encyrtus fuscicollis," *C. R. Acad. Sci. Paris,* CXXVI., 1898, pp. 662–664), although Bugnion ("Recherches sur le développement postembryonnaire, l'anatomie et les mœurs de l'Encyrtus fuscicollis," *Rec. Zool. Suisse,* V., 1891, pp. 435–534, 6 pls.) had previously studied the same insect. Silvestri has published several valuable papers on polyembryony, the most important being "Contribuzioni alla Conscenza Biologica degli Imenotteri Parassiti. I. Biologia del Litomastix truncatellus (Dalm.)," *Ann. R. Scuola Sup. d'Agric. Portici,* VI., 1906, pp. 1–51, 5 pls.

[15] Wheeler, "Ants, their Structure, Development and Behavior," Columbia Univ. Press, 1910. Recently Holmgren ("Termitenstudien, I. Anatomische Untersuchungen," *R. Svensk. Vetensk. Handl.,* XLIV., No. 3, 1909, 216 pp., 3 pls., 76 text-figs.) and Escherich ("Termitenleben auf Ceylon," Gustav Fischer, Jena, 1911, 262 pp., 3 pls., 68 text-figs.) have accumulated much evidence to support the conclusion that the mutual attraction among the individuals and the development of the castes of the termite colony are due to the habit of these insects of feeding on the fatty exudates of one another's bodies and on that of their queens. This may also be true of ants and other colonial insects. A very similar method of feeding on the surface secretions of their host-ants is adopted by certain myrmecophiles (*Oxysoma, Attaphila* and *Myrmecophila*) and certain parasitic ants (*Leptothorax emersoni*).

lids. Dimly foreshadowed in this method of development are the more complete modern types of insect metamorphosis, which have their morphological origin, as we now know, in a doubling of most of the rudiments of the organs in the embryo. On hatching, one set of these rudiments develops immediately into the larval body, while the other set remains in abeyance in the form of minute germinal centers, or histoblasts, from which the body of the adult will be fashioned during the quiescent pupal stage. The higher insects are therefore beautiful examples of double personality, much more perfect examples of this phenomenon, in fact, than any that has been discovered in man. The larval insect is, if I may be permitted to lapse for a moment into anthropomorphism, a sluggish, greedy, self-centered creature, while the adult is industrious, abstemious and highly altruistic, concentrating its activities on reproduction and the dissemination of the species. Unlike ourselves, who are Mr. Hydes and Dr. Jekylls in varying degrees, for brief alternating periods in our lives, or even simultaneously, the youthful insect sows its wild oats with a vengeance as a glutton or even as an assassin and then experiences a change of heart and reforms for good and all.

Parasitism must have been very easily grafted on to such a sharply dichotomic method of development as that of the holometabolous insects, for the larvæ of the predators are already much inclined to sloth and gluttony when the food supply is abundant, and comparatively little modification would be required to convert them into parasites. But the same peculiarities of metamorphosis have also made the holometabolic insects ideal hosts. We have already seen that insects, as a rule, are themselves not only parasitic during larval life, but also prefer larvæ as hosts. It is not improbable that this is the primitive, and that parasitism on the egg, pupa or adult is a secondary, or derivative condition. The real secret of both host and parasite being larvæ lies in the peculiar significance of anabolism in this stage. The host accumulates great quantities of fats and proteids as a so-called "fat-body," which is of little or no immediate use to the organism itself, but is stored up to be utilized during metamorphosis. This fat body may, therefore, be devoured by the parasite and converted into its own fat-body without seriously injuring the host. Furthermore, the fact that the parasite, too, stores up its food in the form of a fat-body instead of at once turning it over to its gonads and becoming reproductive, accounts for the striking differences between the insect parasite, on the one hand, and the tape-worm and *Sacculina*, on the other. The few exceptions among insects, such as the female Strepsiptera, in which the food taken by the larval parasite from its host is soon turned over to the gonads and used for reproduction, leads to a permanent parasitism resembling that of the tapeworms or the adult *Sacculina*. The larva is at once arrested in its development and begins to reproduce by pædogenesis. We may con-

clude, therefore, that the existence of parasites of the *Ichneumon* type, with free, active and highly developed adults is rendered possible by an inhibition of gonadic growth during larval life; whereas parasites which begin to reproduce while still living with their hosts are thereby prevented from either leaving them or undergoing further morphological differentiation.[16]

3. A third primitive peculiarity of holometabolic insects, which seems greatly to have favored parasitism, is the astonishing *rapidity of their larval metabolism and growth* and the equally remarkable *quiescence of their pupal stages.* These have, of course, converted insects into the most wonderful opportunists, through enabling them to take advantage not only of the changing seasons and the very diverse physical conditions of our planet, but also of the most evanescent supplies of food, both living and in process of decomposition.

4. *Parthenogenesis* may also be cited as a widely prevalent phenomenon, which has been put to good use by parasitic insects. Like polyembryony, it has an economic significance, because it enables such noxious parasites as the plant-lice to multiply enormously under conditions that would preclude reproduction in non-parthenogenetic species, and for the same reason greatly assists many Hymenopterous parasites in checking the undue multiplication of these and other plant-destroying insects.

Although I may have had little difficulty in convincing you that parasitism is a very specialized kind of behavior, you will probably still be of the opinion that there is something inherently and radically wrong with animals that resort to it rather than to predatism, mutualism or some other means of maintaining their vital activities. It must, of course, be admitted that in becoming satellites of their hosts, parasites have renounced the primitive, wasteful and erratic freedom of the predator and are compelled to mould their activities on those of the host. This necessarily puts them in a condition of such abject dependence that their very existence as individuals and species is imperilled whenever they overstep that margin of vitality which the host,

[16] This singular ability of the insect to inhibit the development and growth of its gonads till adult life is not only significant in connection with the development of parasitism within the group, but is also of fundamental importance in the development of colonial life among all the social insects. In the worker castes of these organisms the inhibition of the gonads, except under unusual conditions, is simply prolonged into and throughout adult life. Perhaps in last analysis this inhibition is merely a special manifestation of the extraordinary independence of the insect soma and germ-plasm, as has been so beautifully shown in the castration and transplantation experiments of Oudemans, Meisenheimer, Regen and Kopeć. For a discussion of this subject see my paper, "The Effects of Parasitic and Other Kinds of Castration in Insects," *Journ. Exp. Zool.*, VIII., No. 4, 1910, pp. 377–438, 7 figs.

like every other healthy organism, can afford to sacrifice to the accidents of its environment.[17]

The parasite not only tends to restrict itself to the use of a particular host as a food-procuring instrument, but is also compelled to exercise the most exquisite care in the use of this instrument. From the very nature of the situation, therefore, parasitism is an extremely precarious type of behavior. But this is true also of all highly specialized behavior, that of biologists included, and points the way to, but does not constitute, the real difficulty with parasitism. This, I take it, is the suppression of the voluntary movements, which necessarily results from the intimate host relations, especially when these are confined, as is so often the case, to some one particular organ or tissue. It is not, therefore, the parasite's habit of taking something for nothing from another organism, that is so fatal, for all creatures, in matters relating to nutrition, find it more blessed to receive than to give, but the acceptance of the most important supply of its energy under conditions that preclude an exercise of the muscular and hence also of the sensory and nervous activities and restrict its vital activities to a round of assimilation, metabolism and reproduction. This unbalancing of functions is probably hastened by a kind of intraorganismal parasitism or "Kampf der Theile" in Roux's sense, the alimentary and reproductive tissues drawing their nutriment not only from the host but also from the more inactive tissues of the parasite's own body. That this torpor, or inactivity of the neuromuscular system is at the bottom of the peculiar disability of parasites is shown by many non-parasitic organisms, which have easy access to an abundant food supply consisting of dead or inorganic substances. Most plants and many invertebrates, such as the barnacles, and especially the scavengers among insects, exhibit essentially the same modifications as parasites. In fact, the larval stages of many insects that feed on carrion or decomposing animal and vegetable matter, are quite indistinguishable from parasitic larvæ. This and the further fact that plant-eating species are not generally regarded as parasites by entomologists have led to considerable confusion in certain accounts of insect parasitism.

While most parasites among the lower invertebrates have never succeeded in freeing themselves from the tyranny of the host relation and the fatal torpor to which it inevitably leads, this is, as we have seen, by no means true of the typical insect parasites. To the ontogeny of these organisms the dictum "once a parasite, always a parasite" most cer-

[17] Within this "margin of vitality" must also be included the reproductivity of the host species. Thus certain ants, like *Formica fusca*, throughout the north temperate zone, are able to survive the inroads of a number of parasitic ants (*Polyergus rufescens, Formica sanguinea, F. rufa, F. exsecta* and many allied species), largely on account of its great reproductive powers, coupled with an ability to live in the most diverse physiographic conditions.

tainly does not apply. That it is inapplicable to their phylogeny I am not prepared to say, although I am unable to think of any non-parasitic insects that show evidence of descent from parasitic species. There can be no doubt, however, that parasites are still able to give rise to new specific forms. This capacity is without doubt very feeble or languishing in the permanent parasites of the tape-worm and *Sacculina* types as compared with that of the insects. Indeed, there is much evidence to show that in insects, parasitism, far from interfering with the process of species formation, may actually have a tendency to favor or accelerate it. Sharp estimates the number of species of parasitic Hymenoptera on our globe at 200,000, and of this vast number probably 80,000 belong to a single family, the Chalcididæ, of which only some 6,000 species have been described. Another parasitic family, the Tachinidæ, belonging to the great order Diptera, seems to be in such an active stage of species formation that the most diligent and thoughtful students of the group flounder about in it with a dazed and almost ludicrous helplessness. And not only is practically the whole enormous group of moths and butterflies to be regarded as parasitic, but the same is true also of untold legions of plant-lice, scale-insects and beetles. Hyperparasitism, which may be regarded as a kind of permutation of parasitism, must also be mentioned in this connection, because it gives us a glimpse of the virgin fields which the holometabolic insects, owing to their peculiar method of development, are beginning to invade.

I believe that the foregoing discussion of the peculiarities of insect parasites adequately supports the view that these organisms are eminently fitted to function in controlling the depradations of injurious insects. That they can not be regarded as instruments of extermination is obvious from the fact that under natural conditions the complete extinction of the host species involves the destruction of the parasitic species, unless the later is able to live on more than one host. Although it is not improbable that during geological time such joint extermination of host and parasite has repeatedly occurred, we are unable to cite any case that has fallen under the observation of the entomologist. Purely local extermination of injurious hosts by their parasites has, however, been observed.

Before bringing my lecture to a conclusion two matters must be briefly discussed. One of these, which is mainly of theoretical interest, relates to the development of the parasite's association with its host, the other, of more practical significance, to the methods of greatest promise in the study of insect parasitism. We need not stop to consider cases of the tape-worm type which reach their hosts by chance. In the two other types which I have distinguished, we have the association with the host established through the initiative of the larval parasite itself (*Sacculina* type) or through the parasite's mother (insect type). While the former type does not seem to call for any special ex-

planation, there seems, at first sight, to be something mysterious in the insect parasite, for when we see an adult organism, such as an *Ichneumon* coming from a distance—out of the blue, so to speak—and seeking out a concealed larva in which to deposit its egg, we are tempted to turn to some teleological explanation, such as is implied in the common conception of "instinct," or perhaps to something in the nature of a "divinatory sympathy" between parasite and host. Although such conceptions are necessarily anthropomorphic, I would not deny them a certain, albeit provisional, value. As biologists, however, we are fortunately in a position to suggest a simpler explanation. The intimate practical knowledge (*sit venia verbo*) which the mother *Ichneumon* possesses of the host, loses much of its mystery when we stop to consider that she has, during her own larval life, devoured just such an insect, for the same reason that we may be said to have an excellent practical knowledge of an orange after we have eaten it. The *Ichneumon* is therefore familiar with the location, feeling, odor and taste of the creature in which she will lay her eggs, if we make the not improbable assumption that the results of her own larval experience persist as mnemic factors, notwithstanding the profound morphological and physiological changes which she has undergone during metamorphosis. There would then be nothing surprising in her tropism-like reactions to the mechanical and chemical stimuli represented by the host larva and its immediate environment.

As the time at my disposal is nearly exhausted, I must bring my discussion to a close. Having made the pilgrimage to the American Mecca of experimental zoologists, I could hardly hope for salvation if I departed without at least saluting the Kaaba. This I can do most effectively, perhaps, by calling attention to the great need of experimental work in animal and especially in insect parasitology. Biologists, during the romantic period of Darwinism, made much of the parasites. These organisms, in fact, supplied them with no end of ammunition in defence of natural selection, the influence of the environment and the biogenetic law. Then came the period of morphological minutiæ with its tacit assumption that particles of a dead organism are vastly more interesting and illuminating than the whole of a living one. During this period the parasites were, of course, sectioned and studied in the same manner as other organisms, but, since it is impossible to explain a living whole by pulling it to pieces and sticking the inert fragments together again, parasitism, which is a process and not a thing, retained its ethological interest mainly for biologists who were engaged in the practical applications of their science.[18]

Now that we have reached the third period, or that of emphasis on experiment with the living organism as the best means of elucidating

[18] In support of this statement the reader may be referred to the following general articles on insect parasitism, written by well-known economic entomolo-

the life-processes, those of us who had the misfortune to live and exhaust our greatest enthusiasm during the romantic and morphological periods, can, I suppose, do nothing better with the meager remnant of our vitality than pray for breadth of sympathetic vision on the part of our younger, more numerous and more vigorous contemporaries. The splendid achievements of the investigators who assemble here every summer certainly whet one's desire to see experimental work of the same character accomplished in parasitology. A certain amount of simple experimental work on social parasitism in ants has been inaugurated by Wasmann and myself and continued with interesting results by Santschi, Emery, Viehmeyer, Donisthorpe and others, but more important work, having for its object the artificial production of individual parasites and such studies on the behavior of their descendants as those recently made by Kammerer on the offspring of Amphibia, whose breeding habits had been artificially modified, have not yet been undertaken. Here again, as in so many other cases, the botanists are blazing the trail for the zoologists. The familiarity of the former with grafting, which is merely an artificially induced parasitism, has led them to undertake interesting experiments, like those recently published by Pierce[19] and MacDougal and Cannon.[20] And although these experiments yielded less striking results than might, perhaps, have been expected, they nevertheless emphasize an important fact, which all biologists, except systematists and paleontologists, are too apt to overlook, namely, the extraordinary stability of specialized characters.

Experimental zoologists, including the students of animal behavior, are most keenly interested in the modifiability of the organism, and their experiments are usually devised for the special purpose of determining the amplitude and peculiarities of this modifiability. The entomologist, however, who is attempting to use parasitic insects as tools or implements in controlling the depredations of other insects, is primarily interested in the stability of structure and constancy of behavior. This follows from the very nature of his work. As the essential excellence of a tool consists in its remaining the same as it was when it left the hands of the manufacturer, so a parasitic species can be used as an efficient tool only if it behaves generation after generation with uniform constancy. Hence in combating pests, only those

gists in our own country during the period characterized by a very exclusive occupation with morphology in our universities: Riley, "Parasitism in Insects," *Proceed. Ent. Soc. Wash.*, II., No. 4, 1893, 35 pp.; Webster, "Insect Parasites," 15 pp. (reprint without date); Osborn, "Insects Affecting Domestic Animals," Bull. No. 5, U. S. Dept. Agric., 1896, 302 pp., 170 figs.; Howard, "A Study in Insect Parasitism," Tech. Ser. No. 5, U. S. Dept. Agric., 1897.

[19] "Das Eindringen von Wurgeln in lebendige Gewebe," *Botan. Zeitg.*, III., 1894, pp. 169–176; "Artificial Parasitism," *Botan. Gazette*, XXXVIII., 1904, pp. 214–217.

[20] "The Conditions of Parasitism in Plants," Carnegie Inst. Publ., Washington, 1910, 60 pp., 10 pls., 2 text-figs.

parasitic insects can be utilized to advantage that are not only prolific and will endure the climatic conditions into which they have been artificially introduced, but will maintain very definite relations only with individuals of a single or of a very few host species and destroy them in their earliest possible ontogenetic stage before they can do extensive damage.[21] Such constancy is especially necessary in primary and tertiary parasites, since whenever these show a tendency to become secondaries and quaternaries, as is sometimes the case, they become harmful instead of beneficial.[22]

It is clear that the determination of the constancy or invariability of parasitic reactions as a basis for practical applications requires, if anything, an even greater insistence on the experimental method than does the determination of the range and character of modifiability for purely theoretical purposes. Ever since the days of Redi both theoretical and practical entomologists have resorted to the experimental method and therefore have no reason to regard themselves as behind the times in appreciation of what some zoologists have been heralding as a recent dispensation. In other respects, however, the students of insect life are "old fashioned" and resemble the botanists more closely than the zoologists, in that they are constrained by the extraordinary intricacy of their science to maintain the closest and most sympathetic cooperation with the taxonomists, morphologists, and students of geographical distribution. Without this cooperation their studies of insect parasitism would resolve themselves into a weltering chaos.

[21] Howard and Fiske (*loc. cit.*, p. 204) express a similar opinion when they say that "it is probably true also that among those parasites which are the most closely restricted in their host relationships are to be found those which are the most effective in bringing about the control of their respective hosts. This is primarily due to the fact that a correlation usually exists between the life and seasonable history of such a parasite and some one or more hosts which it is particularly fitted to attack. The existence of a correlation between parasite and host of such intimate character makes possible the continued existence of the parasite independently of alternate hosts, and it is thus enabled to keep pace with the one species upon which it is peculiarly fitted to prey when other circumstances are favorable to its increase. Some of the most interesting examples of correlation of this sort which have yet come to attention are to be found among the tachinid parasites of the gypsy moth or the brown-tail moth, and on this account as well as on a purely empirical basis they are now considered much more likely to become important enemies of these hosts than before their characteristics were so well understood."

[22] A very instructive case of such instability in hyperparasitism, or rather superparasitism, is seen in *Pteromalus egregius*, which was introduced into Massachusetts as a primary parasite of the brown-tail caterpillar. This European parasite, as Fiske has recently shown (Howard and Fiske, *loc. cit.*, p. 267 *et seq.*) has not only spread over a great area in eastern New England, since it was first liberated in 1906 and 1907, but besides acting as a primary parasite, it may also behave as a secondary, tertiary or quaternary superparasite.

MATHEMATICS AND ENGINEERING IN NATURE

By Professor ARNOLD EMCH
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WHEN up on the heights, among the imposing wilderness of rocks, crags and pines, the mountaineer is struck by the roaring sound of a storm, he may observe clearly that the weather-beaten trees of a mountain forest, like other organic beings, have to defend themselves against the external attacks of nature. In other words, they have to make provisions to grow in spite of precarious circumstances and to resist many violent disturbances. The adaptability of organic beings to surrounding conditions and the existence of special means of resistance against inner and outer enemies are well known biological facts. That nature in its domain of activity, however, also makes extended use of such principles to which the engineer is accustomed in carrying out his projects, seems to be less generally known. In many instances nature is far in advance of the best human efforts in regard to rational construction. To the eye of the attentive observer, nature even may show pictures which in a beautiful manner reveal definite geometric configurations and relations.

It is not surprising that this should be the case, and might be expected. The axioms of geometry are abstract statements of primitive experiences in space. In fact, according to Picard,[1] geometry may be called the theory of space and, as such, has its origin in experience. Geometric configurations as exhibited by nature are therefore necessarily in accord with the results deduced from the geometric premises. Conversely, within the space of our experience the theorems deduced in ordinary geometry are not contradicted by nature. This statement does, of course, not exclude the possibility of other consistent theories of space, as, for instance, established in the so-called non-Euclidean geometries. The tremendous advantage of the ordinary, or Euclidean geometry, lies in the relative simplicity and adequacy of its application to physical space. As Painlevé[2] states, the science of mechanics, in the philosophical aspect of its foundations, does not differ from that of geometry. Its axioms also are derived from primitive experiences. No science can be created by purely formalistic logic.

Returning to the innumerable objects of natural growth, I shall confine myself to a description of the architectural and mechanical features of a few most conspicuous examples.

The contour-lines of a column or tower, all of whose horizontal

[1] "De la méthode dans les sciences," pp. 1–30, Paris, 1909.
[2] "De la méthode dans les sciences," pp. 336–407.

cross-sections are subject to constant specific stresses, are geometrically defined by cubic parabolas. This form results from the law of stresses under the given conditions, and may be seen in the contour of heavily supporting bridge piers, the Eiffel tower in Paris and numerous other structures. Precisely the same problem nature has solved in building the trunks of tall trees. The famous coniferous trees of California (Fig. 1) offer the best illustration for this principle. The reason for this lies in the fact that the maximum strength of the material used in one and the same engineering structure, or in a tree, being a known constant, it is evidently of the greatest economic advantage to make the specific stresses throughout as uniform as possible.

FIG. 1.

To resist great lateral bending forces, or moments caused by strong and irregular winds, the large trees of the forest are equipped with powerful wind-struts near the base and extending to the anchoring roots (Figs. 2 and 3). The same thing the architect does when he provides for buttresses in Gothic buildings, or when he reinforces the base of a column to secure lateral stability. The more the trees are exposed to the winds, the larger the crown, the more the principle of buttresses and pillars assumes its functions. Wherever winds from a certain direction prevail, one notices plainly that in such a region the wind-struts of the trees on the side opposite to the attack of the wind are most strongly developed. In mountainous regions where on account of the rough character of the surface, the winds are very turbulent and are making their attacks in violent gusts from all directions, one may observe wonderful and grotesque shapes of root-stocks. In a seemingly almost impossible manner the roots crawl over each other, over rocks

and around irregular cliffs, simply to find in a crack some ground for anchorage (Fig. 3).

From a technical standpoint also the cell structure of trees and other plants must be considered as a wonderful manifestation of the resources of nature.[3]

FIG. 2.

In this respect, the stalk of a rye-plant may be mentioned as a typical example. This plant meets the same requirements that are

[3] Schwender, "Mechanische Probleme der Botanik," Leipzig, 1909.

necessary in the construction of a high tower. The base of the whole structure is subject to the pressure of the entire load above, and must be able to resist it by compressive strength. Horizontally inserted beams, carrying loads, must have strength to resist bending. There are, furthermore, forces of gravity and all kinds of strains, caused by shearing and torsional forces, which must be accounted for. Considering the fact that in the growth of a rye-plant nature provides completely for the resistance against this complicated system of stresses, and com-

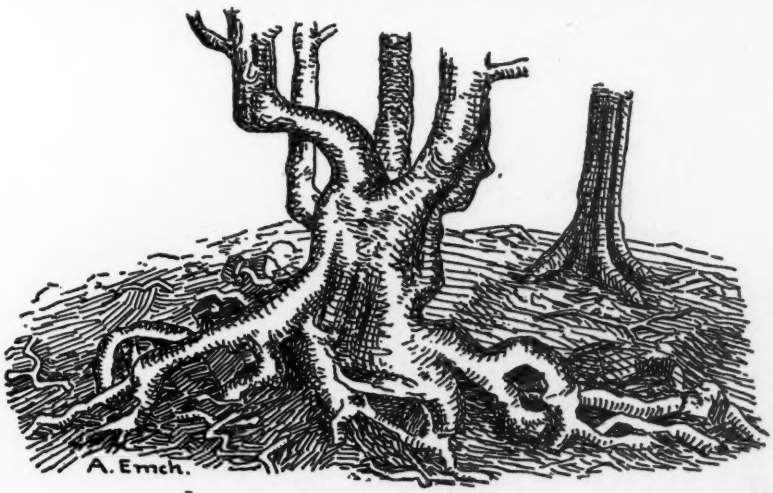


FIG. 3.

paring this kind of engineering with corresponding human efforts, then even the famous and much admired Eiffel tower appears as a relatively large and clumsy structure.

According to Francé,[4] a rye stalk has an average height of 1,500 millimeters and a diameter of 3 mm. at the base. This, transformed to the proportions of architecture, means that nature has here established a structure which in comparison is 33 times the height of one of the towers of the Cathedral of Cologne. Imagine now that at the top of such a colossal tower a proportionally large and heavy ear of rye be pendling, and we get an idea of the amount of compressive, tensile and bending strength a plant-stalk may acquire. We become aware that the plant, with extreme perfection, applies the same principles with which the engineer is working. One discovers relations which the engineer finds in studying moments of inertia, bending moments, etc., in beams, girders, columns, and all kinds of trusses. Thus the plant produces extremely complex structural phenomena, which, from the standpoint of the engineer, reveal a masterful knowledge of the laws of mechanics and the consequent economy of materials. The same statement applies to the physiological problems of zoology.

[4] "Illustrierte Zeitung," 1909.

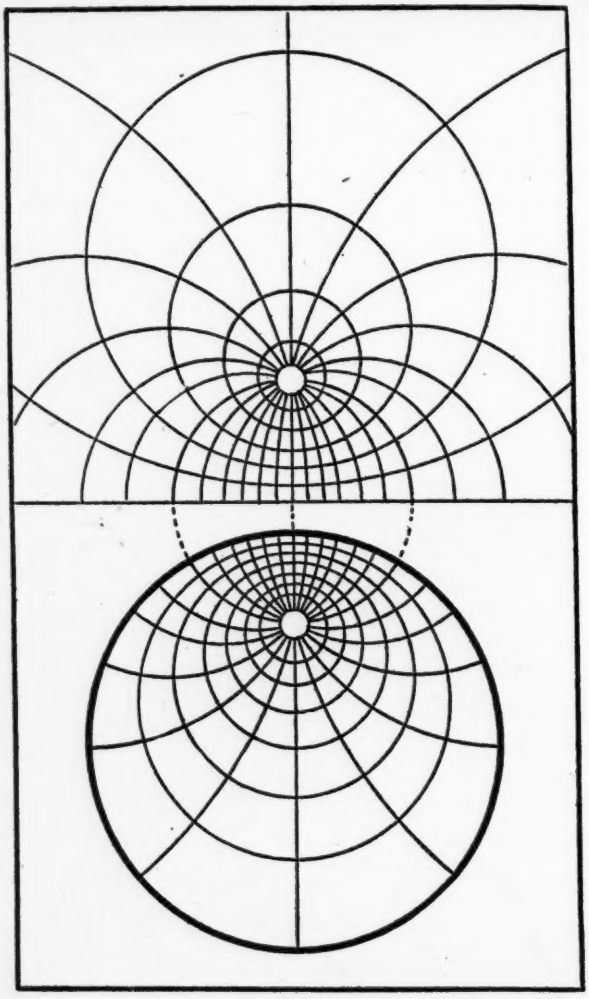


FIG. 4.

While in the foregoing examples special stress was put on the relative identity of mechanical principles in engineering and nature, it will, in the next place, be interesting to show that in many cases the laws of rational construction and design are at a glance geometrically apparent.

If we think of the cross-section of a tree, further growth must necessarily occur in directions normal to the surface of the last year-ring. This causes the year-rings and pith-rays to form a system of orthogonal trajectories. In Fig. 4 such a system, consisting of two conjugate pencils of circles, is shown, and is caused by a rate of growth greater in one direction than another.

The inner yellow portion of a daisy (*Chrysanthemum leucanthemum*) exhibits a beautiful geometrical arrangement of its elements. By the mathematical principle of conformal transformations it can

easily be proved that the best distribution of the elements is obtained when the lines appearing in the configuration of the flower (Fig. 5) are logarithmic spirals.[5]

In a similar manner the location of the leaves along the stem of a plant is determined by remarkable numerical relations.[6] The fraction n/m expressing the parts of the circumference by which consecutive leaves are separated are constant for each species and are the successive approximations of the continued fraction

$$\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+\cdots}}},$$

i. e., $1, \frac{1}{2}, \frac{2}{3}, \frac{3}{5}, \frac{5}{8}, \frac{8}{12}, \cdots$, which, on the other hand, are also the terms of a special Lamé's series. Arranging the leaves according to these fractions, nature insures for each species the best distribution of light and masses, and consequently the best growth.

Helical motion in the growth of certain plants around supporting poles may be explained mechanically. The outer parts exposed to the light grow faster than the inner portions, with the resulting tendency to bend the stem around the pole. This, combined with the upward growth, produces the spiral motion. The fact that most climbing plants, with a few exceptions (hops, *Polygonum convulvulus*, etc.), show left-handed twisting may be circumscribed by calling it "geo-

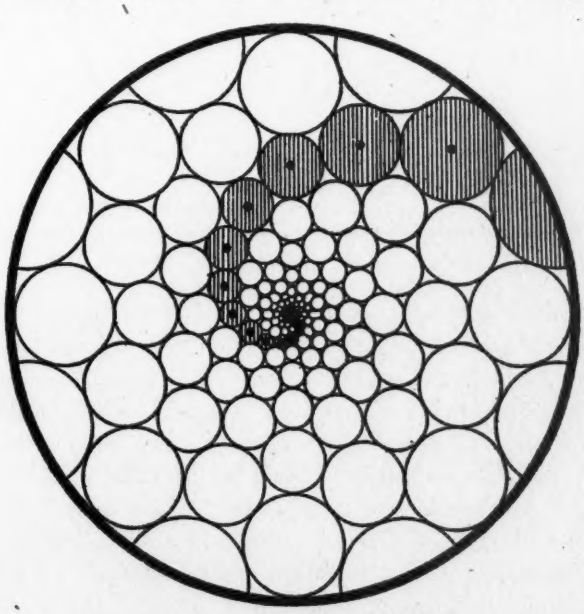
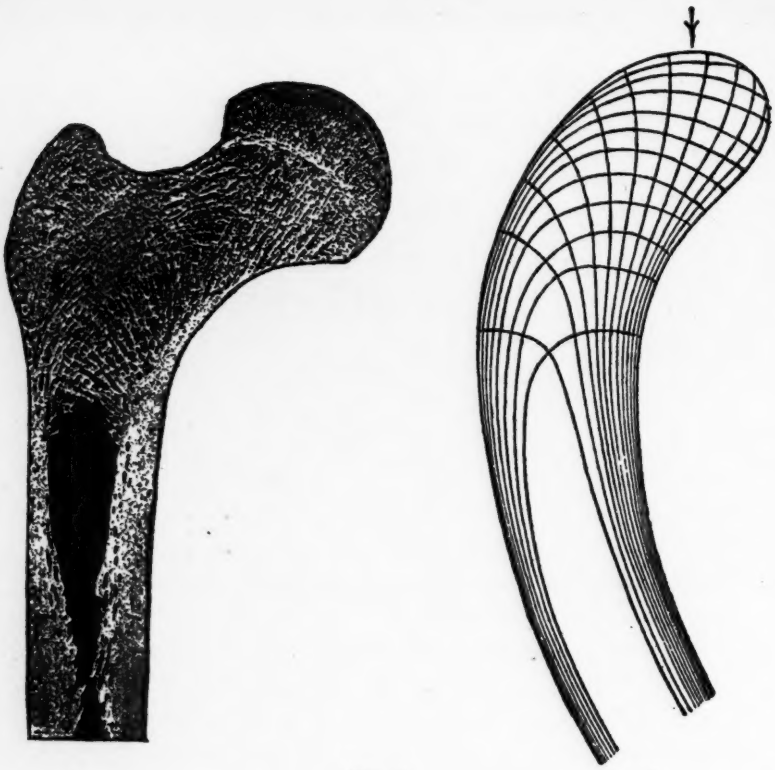


FIG. 5.

[5] Emch, "L'Enseignement Mathématique," Vol. 7, p. 722 (1910).

[6] Strassburger, "Lehrbuch der Botanik für Hochschulen," pp. 31–35.



a FIG. 6. b

tropism." This, however, does not give a mechanical reason for it; not more so than for the left-handed spirals of snail-shells. In the Rocky Mountains I have often noticed this peculiar tendency in the uniform twisting of the fibers of the Lodge Pole pine.

The plain appearance of geometric configurations and relations is, of course, not limited to plant life alone; mineralogy, zoology and geology also offer many examples of this kind.

The forms of crystals, for instance, may be derived abstractly from certain considerations in the theory of groups.

Mendel's law of heredity has in recent years become of extreme importance as a powerful means of research.[7] The abstract form of this law is derived from combinatory analysis, as will appear from the following experiment of L. Cuénot.[8] All individuals of the offspring resulting from the crossing of the ordinary gray mouse with the albino mouse are gray; the gray element *G* dominates, while the white element *W* is hidden by the gray. Crossing individuals of the offspring, among the new offspring there will be gray and white specimens, and the ratio

[7] Lang, "Uber die Mendelschen Gesetze, etc.," *Schweiz. Naturf. Gesellsch.*, Luzern, 1905.

[8] *Revue Scientifique*, Paris, 1906.

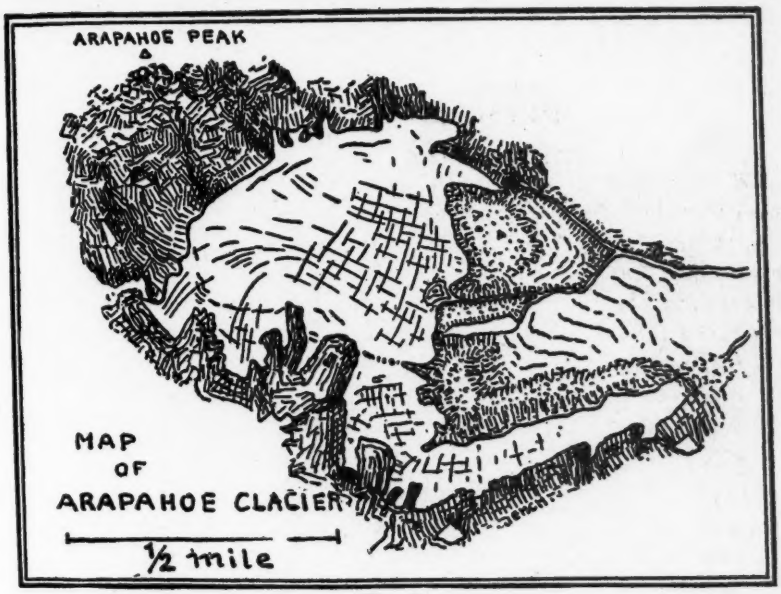


FIG. 7.

of their respective numbers is generally 3 to 1. To explain this fact, first observed by Mendel, the hypothesis is made that in crossing the specific sexual elements merely associate and do not form a new uniform individual element. Among the *G*- and *W*-elements, in equal numbers, the following combinations are possible during the act of generation:

G and *G*,
G and *W*,
W and *G*,
W and *W*.

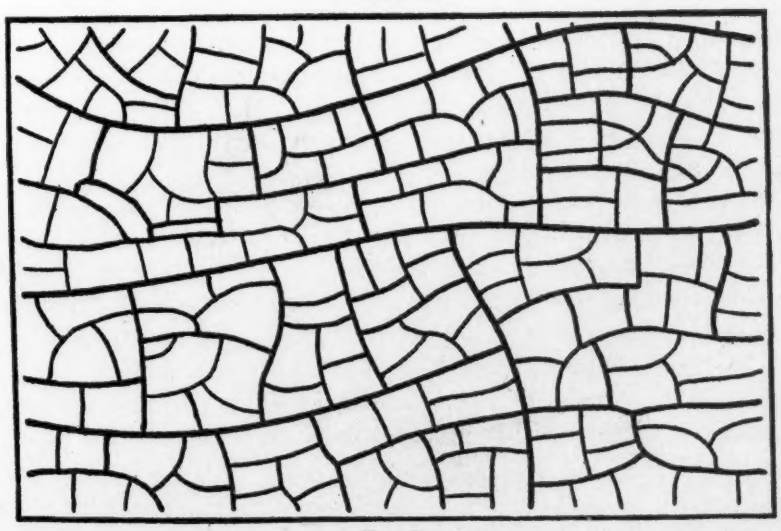


FIG. 8.

Each of these combinations is the starting point for a new individual. It will be gray if there is a dominant G in the combination. Hence, among the offspring there will be three gray and one white. The result may be expressed by the formula

$$GW \cdot GW = 1GG + 2GW + 1WW,$$

which is corroborated by similar experiments of other investigators.

In graphic statics, one of the most valuable branches of structural engineering, may be found the reason for the peculiar distribution of the substance in the upper portion of a thigh-bone along orthogonal trajectories (Fig. 6 *a*). This is in analogy with the problem of a crane-like structure, as diagrammatically shown in Fig. 6 *b*. It is well known that the curves of maximum compression and tension in a strained body form an orthogonal system,[9] and it seems natural that in order to insure greatest strength, cell matter should be deposited according to this system.

An orthogonal system formed by the stream lines and lines of greatest tension, which appear as lateral cracks and crevasses, is shown in most glacial movements (Fig. 7). The directions of corresponding stresses and sections upon which they act form an involutoric pencil of rays. The case where the field is exclusively subject to tensions only leads to elliptic involutions around all points. Every involutoric pencil admits of a rectangular pair, corresponding to the maximum and minimum stresses; tensions in this case. The effect of this condition is shown in Fig. 8, representing the cracks of a mud-bed or on a heavily varnished surface which is drying up. In this case only tensile normal stresses act on the rectangular pair. One is a maximum, the other a minimum. After a crack has formed, the maximal stress and strain normal to the crack has been relieved, so that the former minimal normal tension along the crack becomes now the maximum. The next rupture will therefore be orthogonal to the first crack. The reason for this peculiar configuration is thus found by the methods of projective geometry.[10]

A great number of other examples from the realms of natural history might be added which all would give further evidence of the fact, that the whole evolution of the inventive and creative human intellect is reflected by the well-perceived phenomena of nature.

By the laws of the universe the human mind is forced to repeat the same logic conclusions, according to which the rest of the organic world and nature in general manifest themselves.

[9] Ritter, "Graphische Statik," Vol. 1, pp. 128–134.

[10] Emch, "An Introduction to Projective Geometry and its Applications," pp. 239–241, New York, 1905.

AMERICAN MATHEMATICS

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ABOUT a dozen years ago a well-known French mathematician wrote as follows in reference to our mathematical situation:[1] "Mathematics in all its forms and in all its parts is taught in numerous [American] universities, treated in a multitude of publications, and cultivated by scholars who are in no respect inferior to their fellow mathematicians of Europe. It is no longer an object of import from the old world but it has become an essential article of national production, and this production increases each day both in importance and in quantity."

Taken by itself this assertion looks good and it is doubtless more nearly true to-day than it was at the time of publication. If we turn our eyes away from this statement and rest them upon the mathematical book shelves of a good library, we can not fail to notice that our accomplishments do not seem to be in accord with the complimentary statement noted above. This disaccord will become still more evident if we look through the pages of some of the standard works of reference, such as the great mathematical encyclopedias which are now in the course of publication.

If a student of the history of mathematics would make a list of the leading mathematicians of the world during the last two or three centuries, arranging the names in order of eminence, he would have a fairly long list before reaching the name of an American. Such names as those of Euler, Cauchy, Gauss, Lagrange, Galois, Abel and Cayley have no equals in the history of American mathematics; and, among living mathematicians, probably all students would agree that there are no American names which should be placed on a mathematical equality with those of Poincaré, Klein, Hilbert, Frobenius, Jordan, Picard and Darboux. Both of these lists of names could be considerably extended without any danger of being unfair to the mathematicians of this country, but they suffice to establish the fact that our mathematical situation is not yet satisfactory, notwithstanding our remarkable progress during recent decades.

This unsatisfactory situation is reflected in many of our standard books of reference. For instance, under such an important word as "matrix" one finds in Webster's New International Dictionary (1910)

[1] Laisant, "La Mathematique, Philosophie-enseignement," 1898, p. 143.

the following statement: "The matrix has also significance apart from its development into a determinant." In view of the fact that a matrix, as commonly used by mathematicians, has no possible development, it is clear that the given sentence does not convey any information. In fact, the other remarks under this term are almost equally objectionable, and they raise the question whether a philosopher should be selected to define the mathematical terms of a standard work.

It is not implied that such an extensive work as a large dictionary could be expected to be free from defects, but there is always a limit to the number and the type of those which appear excusable. When one reads in such a dictionary that "algebra is that branch of mathematics which treats the relations and properties of quantity by means of letters and symbols," and then turns to page 22 of volume 1 of the large French mathematical encyclopedia and reads that "it is convenient, in arithmetic, to represent any number by a letter, it being understood that this letter denotes a single and the same number whenever one remains in the same subject," it becomes evident that the given definition of algebra is not supported by some of the highest authorities.

In fact, such terms as arithmetic, algebra and geometry are used with such a wide range of meanings by eminent authorities that it seems impossible to give satisfactory definitions of them, and our dictionaries would convey more reliable information about mathematical terms by stating this fact, together with some indication of what broad subjects are generally classed under these terms, than by giving categorical definitions which can be accepted only by those who have a meager knowledge of mathematics.

Without implying that Webster's New International Dictionary is any less reliable with respect to mathematical matters than most others, we shall refer to one more instance of misleading statements in this work. On page 2547 we read as follows: "The cipher was originally a dot, used as a mere arbitrary sign to mark place or local value." Such a definite statement seems strange in view of the fact that the origin of zero is one of the unsettled questions of the history of mathematics. It is of interest to note in this connection that Cantor changed his view with respect to the origin of this concept and this symbol, in the third edition of Volume I. of his classic "Vorlesungen ueber Geschichte der Mathematik," where he states that the symbol for zero and the positional arithmetic are probably due to the Babylonians instead of to the Hindus, as he had stated in the earlier editions of this work, and as is stated in a large number of other works.

Our encyclopedias also frequently exhibit careless editing along the line of mathematical terms, and the choice of editors for such work often seems to indicate that the general editor regarded the choice of the mathematical editors as a matter of little consequence. Possibly

those who would be best qualified to render excellent service along this line are unwilling to undertake it in view of the large amount of labor which it involves.

As an instance of a decided misstatement in one of the best of these encyclopedias we may cite the following: "Sylow (1872) was the first to treat the subject [substitutions] apart from its applications to equations."[2] Very little reading along the line of the development of the theory of substitutions would reveal the absurdity of this statement. Nearly all of Cauchy's fundamental work along the line of substitutions was no more intimately connected with the theory of equations than the articles by Sylow. Similar remarks apply to most of that part of Jordan's work which antedates Sylow's fundamental article, and also to the work of a number of other authors.

Judging from the following words of Sir Oliver Lodge; "the mathematical ignorance of the average educated person has always been complete and shameless,"[3] one could not expect to find very much better conditions in England. In fact, in consulting the large Murray English Dictionary, published at Oxford, England, the writer found under the first mathematical term which he consulted, viz., the word "group," not only an incomplete definition, but also the following incorrect statement: "The idea of group as applied to permutations or substitutions is due to Galois." As a matter of fact, the idea of permutation groups was clearly developed by Ruffini about thirty years before Galois, not to mention the still earlier work by Lagrange and the early publications of Cauchy and Abel.

One of the most direct inferences from what precedes is the fact that there is too much mathematical indifference. If more vigorous protests against the inaccuracies in our standard books of reference would be made, publishers and general editors would doubtless exercise greater caution in the selection of their mathematical editors. This mathematical indifference is perhaps still more disastrous when it exists among university administrators. Judging from several of the recent appointments in leading universities, it would appear that we are not moving as rapidly towards high mathematical ideals as one might wish.

The English-speaking pure mathematicians constitute more nearly a terra incognita than the workers in any other large field of knowledge. This is partly due to the nature of the subject and partly to the fact that there are so few mathematical works of reference in the English language. There never has been a good mathematical encyclopedia or other work of general reference in this language, while the French and Germans have had several such works in addition to the great encyclopedias which are now in the process of publication. All large mathematical histories have appeared in foreign languages.

[2] New International Encyclopedia (1904), under "Substitutions."

[3] "Easy Mathematics," 1906, preface.

As a result of this lack of intermediate mathematical literature comparatively few of our people know what constitutes a mathematician of high order. The time has been when even the educated public seemed to believe that the author of a successful series of elementary text-books had necessarily gained a place among the great mathematicians of the world. As several of our most popular recent series of text-books were edited by men of remarkably low mathematical attainments, this view is no longer so generally held, but it is questionable whether it has been replaced by a more correct one on the part of the majority of those who feel entitled to express an opinion on the work of mathematicians.

In looking over the work of the fourteen great mathematicians mentioned above one finds that all of them published mathematical articles and that a majority of them also published treatises. Two of them, Abel and Galois, died at an early age, before they had time to develop sufficiently the fields in which they were interested to write extensive treatises. This is especially true of Galois, who published only five papers during his short lifetime of only twenty years, but several of his other papers appeared later.

The extent of the publications of the mathematicians mentioned above varies from the comparatively few brief articles by Galois to the voluminous publications by Euler, which are just now appearing in a collected form and are expected to fill forty large volumes. Judging from the great mathematicians of the recent past, it would appear that publication of original articles is one essential of greatness, but greatness is not measured so much by the number and the extent of such publications as by their merits. It should, however, be observed that nearly all of the great mathematicians of the recent past have published a large number of research papers. In the case of Cayley, who is the only Englishman in the given lists, the number of these papers is about one thousand.

America has never had a mathematician who published as extensively as some of the European mathematicians, and the average extent of our publications is much below the average of the leading mathematical countries of Europe, if we exclude the elementary text-books. It is doubtless true that the most important consideration at present is the improvement of the quality of our publications, but we are also in need of more mathematical journals to insure more rapid publication of good research material. If the crowded condition of our research journals would induce a larger number to assist in bringing out more good intermediate mathematical literature, it would doubtless be of great importance for the future advancement of the science.

One of the leading agencies in bringing about rapid mathematical advances during the last few decades is the American Mathematical

Society, which is now one of the strongest mathematical societies of the world and has probably a larger income than any other similar organization. It publishes two journals and its frequent meetings furnish favorable opportunities to renew zeal and to cooperate in the more important advances. These meetings serve also as a good medium to spread reliable information in reference to young men of promise and to secure for them more prompt recognition than would otherwise be possible.

One of the most hopeful signs as regards American mathematics is the fact that our students are in close contact with several of the mathematical centers of Europe. It is no longer true that nearly all Americans who go abroad for the purpose of studying mathematics locate in the same institution or in the same country. In recent years, Italy has grown rapidly in favor, while the leading universities of Germany and France continue to attract a considerable number of our best students. The rapid interchange of ideas resulting from the scattering of our mathematical students in foreign countries is doing much to dispel prejudices, to make American mathematics cosmopolitan, and to awaken a keener appreciation of the advantages and the disadvantages of our own institutions.

If one bears in mind the facts that our library facilities were very poor until recent years and that no locality offers in itself any special inducements for mathematical study, one should perhaps be surprised by the rapid mathematical advances during the last few decades rather than by the fact that we have not yet attained to greater national eminence. It remains to be seen whether we shall ever be on an equality with the leading mathematical nations of the world. The rapidity with which we have obtained respectful recognition and the American eminence in some of the other sciences might reasonably awaken the hope that we may be not far from the time when we shall deserve, in the strictest sense, the position pictured in the first paragraph in such a friendly spirit.

BUFFON AND THE PROBLEM OF SPECIES

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I

THERE is no chapter of the history of the theory of organic evolution more confused or more controverted than that which relates to the position of Buffon. Upon one point, indeed, nearly all expositors of the "Histoire Naturelle" are agreed—namely, that Buffon's own expressions on the subject, if taken at their face value, contradict one another. But upon the questions whether his utterances were meant to be taken at their face value; whether, by a due consideration of dates, the contradictions can not be regarded as consecutive steps in a logical progress of doctrine; whether he was in the main a partisan or an opponent of transformism: upon these questions both the biographers of Buffon and the historians of evolutionism are greatly at variance.

The rival interpretations fall into six groups: (1) Older writers of the anti-evolutionary school, such as Cuvier and Flourens, while admitting that (in the words of Flourens) "the ideas of Buffon were constantly subject to profound mutations," were wont to maintain that in the last analysis and in the long run he must be counted among the defenders of the doctrine of immutability of species. Among recent writers Packard gives a similar account; while he recognizes "tentative" evolutionistic utterances in the "Histoire Naturelle," he opines that Buffon himself "did not always take them seriously, but rather jotted them down as passing thoughts." (2) One of the earlier French evolutionists, Isidore Geoffroy St. Hilaire,[1] contended that there was no mere fluctuation in Buffon's teaching, but simply an orderly movement of thought from one position to another.

> Buffon does but correct himself; he does not fluctuate. He goes forward once for all from one opinion to another, from what at the outset he accepted on the authority of another to what he recognized as true after twenty years of research.

The successive phases of opinion through which, according to Isidore Geoffroy, Buffon passed were three. At the beginning of his work (1749) and down to 1756 or later, he "still shared the views of Linnæus" and affirmed consistently the theory of immutability. From 1761 to 1766 he asserted the hypothesis of variability in an extreme form. Later he became convinced that "in setting himself free from the prevailing notions," he had, "like all other innovators, gone some-

[1] In his "Histoire Naturelle Générale," Vol. II., 1859. His account is translated in Butler's "Evolution Old and New."

what to the opposite extreme"; and in all his writings subsequent to 1766 he held to a doctrine of "limited mutability," to the "permanence of the essential features" of species and "the variability of details." This division of Buffon's opinions into three periods, of which the middle one was characterized by an extreme evolutionism, has been accepted by a number of later writers. It is apparently adopted by Osborn, though not to the exclusion of other interpretations inconsistent with it.[2] (3) By several recent writers—such as Samuel Butler, de Lanessan, Giard, Clodd—Geoffroy's scheme of three periods is rejected, and Buffon is declared to have been an evolutionist throughout virtually his whole career as a writer. Those who take this view explain away his apparent self-contradictions by various suppositions. Giard, for example, holds that Buffon began as a transformist, but was led by his difficulties with the ecclesiastical authorities (in 1751) to conceal his real position for a number of years, becoming bolder and more outspoken after 1761, when his fame was securely established. In other words, Giard proposes an alternative division into three periods, in which the middle phase is the *least* evolutionistic. Samuel Butler, who has taken the most extreme ground of all in favor of the view that Buffon was a whole-hearted evolutionist, endeavors at great length and with much ingenuity to show[3] that all the anti-evolutionary passages in the "Histoire Naturelle" are ironical. According to this interpretation Buffon must almost be said to have woven a sort of cryptogram into his work. "His irony is not the ill-natured irony of one who is merely amusing himself at other people's expense, but the serious and legitimate irony of one who must either limit the circle of those to whom he appeals, or must know how to make the same language appeal differently to the different capacities of his readers, and who trusts to the good sense of the discerning to understand the difficulty of his position, and make due allowance for it." In other words, Buffon threw in sufficiently frequent affirmations of the immutability of species to deceive, or at least to quiet, the doctors of the Sorbonne, and in the very act of doing so he made it evident to the judicious reader that the opposite conclusion was the one to be accepted.

The three remaining interpretations of Buffon's position are less subtle and ingenious. (4) The author of the most comprehensive recent history of biological theories[4] tells us that, though Buffon "speculated about the origination of one species from another," he did not "especially interest himself in the question of the mutability of species; his too little developed sense for the historical [*i. e.*, the genetic] aspect of nature did not permit him to put clearly before himself such a question as that concerning the origin of species. How should he have done so, since he did not even believe in the existence of species, but recog-

[2] "From the Greeks to Darwin," 130–135.

[3] In his "Evolution Old and New."

[4] Rádl, "Gesch. der biologischen Theorien," I., 1905, pp. 117–118.

nized only individuals?" (5) Dacqué, in what is at many points the least inaccurate of the histories of evolutionism,[5] declares that Buffon brought forward no more profound ideas than his contemporaries "upon the interconnection of the phenomena of organic nature," though he did something to clarify the conception of geological evolution, and "regarded species as variable within certain limits." (6) The writer who (so far as I know) has most recently discussed the subject, Landrieu,[6] seems finally to give up as hopeless the attempt to reduce Buffon's utterances to harmony and coherency.. He adds, however, that in spite of these inconsistencies, "Buffon retains the indisputable honor of having been the first zoologist to admit the possibility of specific variations due to environmental influences and extending beyond the limits of species."

All of these accounts of the matter seem to me to be either inadequate or erroneous, though all may be said in some measure to be founded on fact. Most of them—especially of the more recent ones—wholly ignore two essential considerations in relation to Buffon's biological conceptions, in the light of which all that he wrote must be interpreted. In attempting to present a more adequate and more correct analysis of Buffon's opinions, I shall be obliged to tax the reader's patience with many and lengthy citations. Where there has been so much disagreement, it is necessary to present the proofs for nearly every statement propounded. And where so much error has arisen through the citation of brief passages in disregard of their contexts, it is important that pains be taken to quote or summarize so much of each text as appears to be in any way relevant to the question under consideration.

1. The first volume of the great treatise (1749) opened with a preliminary disquisition on the methodology of the science, a "Discours de la manière d'étudier et de traiter l'histoire naturelle." In this Buffon gave a salutary emphasis to the demand for a more "philosophical" way of studying botany and zoology than had been exemplified by Linnæus and Tournefort and the other great systematists. Description and classification, Buffon insisted, were the least part, though a necessary part, of "natural history."

> We ought to try to rise to something greater and still more worthy of occupying us—that is to say, to *combine* observations, to generalize the facts,

[5] "Der Descendenzgedanke u. seine Geschichte," 1903—a little book less known than it deserves to be.

[6] In his "Lamarck, fondateur de l'évolution," 1909, pp. 275–283. May I improve this occasion to express the hope that both French and English writers may some day be broken of the habit of talking of "evolution" when they mean "evolutionism"? Both languages chance to be provided with a suffix for distinguishing a theory which affirms, or relates to, a given fact from the fact itself; it seems a pity to throw away this instrument of linguistic precision. It is surely absurd (not to say profane) to speak of Lamarck or any other mortal as "the founder of evolution"; or of the eighteenth century as "the beginning of evolution."

to link them together by the force of analogy, and to endeavor to attain that high degree of knowledge in which particular effects are recognized as dependent upon more general effects, nature is compared with herself in her larger processes, and thus ways are opened before us by which the different parts of physical science may be perfected. For success in the former sort of study there are needful only a good memory, assiduity and careful attention; but for the sort of which we are here speaking other qualities are requisite: breadth of view, steadiness of vision, a power of reasoning formed by the practise of reflection even more than by learning. For such study, in short, a man must have that quality of mind which enables him grasp remote relations between things, to bring them together, and thereby to form a body of reasoned conclusions, after having duly estimated similarities and weighed probabilities.

But these judicious and stimulating, if slightly vague, appeals for the conversion of natural history into a science of causal relations and generalized laws, were not the principal purpose of the preliminary discourse. The thought of Buffon at the time when he wrote that essay seems to have been dominated above all by a single idea, which was also one of the two or three ruling ideas of the whole of the first half of the eighteenth century—namely, the Leibnitian "principle of continuity" (*lex continui*). In the intellectual fashions of this period, next to the blessed word "Nature" the most sacred phrase was "the Great Chain of Beings"; indeed, one of the truths that man was supposed to know most surely about nature was that she "makes no leaps." In the form, especially, of the neo-Platonic and Spinozistic metaphysical assumption that all possible forms must exist, the principle was much older than the philosophy of Leibniz;[7] but it owed to him and his disciples a more definite formulation and a greatly increased popular currency. It declared that all entities are arranged in a graded scale of similarity, so that for every being that exists there also exists some other (in the strict version of the principle, one and only one other) from which its difference is infinitesimal, *i. e.*, less than any assignable difference. A typical statement of the doctrine is Bonnet's:[8]

Between the lowest and the highest degree of corporeal or spiritual perfection there is an almost infinite number of intermediate degrees. The series of these degrees constitutes the *Universal Chain*. It unites all beings, binds together all worlds, embraces all spheres. One Being alone is outside of this chain, and that is He who made it. . . . There are no breaks (*sauts*) in nature; all is graduated, everything shades off into the next thing. If, between any two beings whatever, there existed a gap, what would be the reason of the transition from the one to the other? There is, therefore, no being above or below which there is not some other that approximates it with respect to some characters and diverges from it with respect to others.

All this (as Bonnet's language intimates) was held by the Leibnitian philosophy to be logically implied by the still more fundamental "principle of sufficient reason." For if the gradations found in nature

[7] This implied that there must be one, and can be only one, sample of every possible kind or degree of entity. To consider Leibniz's attitude toward this form of the principle would involve too much technical metaphysics.

[8] "Contemplation de la Nature" (1764), 2d ed., 1769, I., 26–27.

were discontinuous, if between any two beings an intermediate type were logically capable of existing, but actually non-existent, the universe would stand convicted of irrationality. A thing for the existence of which there was just as much "reason" as there was for the existence of certain other things would have failed of realization, while the others arbitrarily enjoyed the privilege of actuality. The principle of continuity owed its vogue in part, also, to the influence of the Leibnitian calculus, which had brought infinitesimals and the notion of the continuum peculiarly into fashion.

Applied primarily to the "monads" of Leibniz's metaphysics, the principle found a multitude of other applications. It served, for example, as the chief basis of the arguments for optimism of which the early eighteenth century was so fond. Pope's "Essay on Man" is full of the argument from the necessity of continuity to the necessity of imperfections and apparent evils.

> Vast chain of being! which from God began;
> Nature's ethereal, human, angel, man,
> Beast, bird, fish, insect, whom no eye can see,
> No glass can reach; from infinite to thee,
> From thee to nothing. On superior powers
> Were we to press, inferior might on ours;
> Or in the full creation leave a void,
> Where, one step broken, the great scale's destroyed.

For the limitations of man's lot the sufficient consolation is that the principle of continuity requires them; in a system

> Where all must full or not coherent be,
> And all that rises, rise in due degree,—
> Then in the scale of reasoning life 'tis plain
> There must be, somewhere, such a rank as man.

From the assumption of the same principle sprang the inquiries from which the science of anthropology may be said eventually to have originated. As a historian of the beginnings of that science has said:

> The question concerning the line of demarcation between man and the animal kingdom was plainly forced upon anthropology by the philosophy of Leibniz. The *lex continui* demanded the discovery of that "grade" (*nuance*) of existence among the higher organisms which comes nearest to the human species. And so there began the celebrated quest of the "missing link." In the first phase of this quest, the missing link was sought at the lower limits of humanity itself. It was held to be not impossible that among some of the more remote peoples semi-human beings might be found, such as had now and then been described in travelers' tales. Some voyagers had testified to having seen with their own eyes men with tails; others had encountered tribes incapable of speech. Linnæus mentions a *homo troglodytes* concerning whom it was not established with certainty whether he was more nearly related to the pygmies or to the orang-outang. The most eminent men of science down to a late period in the eighteenth century hesitated to reject absolutely the possibility of the existence of such beings.[9]

[9] Günther, "Die Wissenschaft vom Menschen im 18ten Jahrhundert," p. 30.

It was, then, the application of this principle to natural history that was Buffon's main object in his preliminary discourse. The consequences of it, when it was applied in this field, were simple and evident and drastic: there can be no such thing as a "natural," or even a consistent "system" of classification, since there are no sharp-cut differences in nature, and since, therefore, species and genera are not real entities but only figments of the imagination. It is easy, Buffon wrote, to see the essential fault in the work of the systematists, the inventors of "methods" as a class.

> It consists in an error in metaphysics in the very principle underlying these methods. This error is due to a failure to apprehend nature's processes, which take place always by gradations (*nuances*), and to the desire to judge of a whole by one of its parts.[10]

Man, placing himself at the head of all created things and then observing one after another all the objects composing the universe,

> will see with astonishment that it is possible to descend by almost insensible degrees from the most perfect creature to the most formless matter; . . . he will recognize that these imperceptible shadings are the great work of nature; he will find them—these gradations—not only in the magnitudes and the forms, but also in the movements, in the generations and the successions, of every species.[11] If the meaning of this idea be fully apprehended, it will be clearly seen that it is impossible to draw up a general system, a perfect method, for natural history. . . . For in order to make a system or arrangement, everything must be included, and the whole must be divided into different classes, these classes into genera, and the genera into species—and all this according to an order in which there must necessarily be something arbitrary. But nature proceeds by unknown gradations, and consequently can not wholly lend herself to these divisions—passing, as she does, from one species to another species, and often from one genus to another genus, by imperceptible shadings; so that there will be found a great number of intermediate species and of objects belonging half in one class and half in another. Objects of this sort, to which it is impossible to assign a place, necessarily render vain the attempt at a universal system.[12]

In short, the whole notion of species is inconsistent with the conception of nature as a graded continuum of forms in which there are no breaks.

> In general, the more one increases the number of one's divisions, in the case of natural products, the nearer one comes to the truth; since in reality individuals alone exist in nature, while genera, orders, classes, exist only in our imagination.[13]

The vogue of the principle of continuity in the eighteenth century

[10] "Hist. Nat., Vol. I., 1749, p. 20.

[11] These words are Buffon's nearest approach in the introductory discourse to a suggestion of the mutability of species. De Lanessan has interpreted them as an affirmation of transformism; but they are too vague to justify such a construction.

[12] "Hist. Nat.," Vol. I., 1749, p. 13. Much the same thing had, however, been said by Ray over sixty years before; cf. "Historia Plantarum," 1686, I., p. 50.

[13] *Op. cit.*, p. 38.

was, unquestionably, an important influence tending to prepare men's minds for the acceptance of the conception of evolution; but the two doctrines were by no means synonymous, nor did the adoption of the former necessarily imply adherence to the latter. The *lex continui* is historically important because it led to one of the early notable departures in modern thought from what may be called a Platonistic habit of mind, that had, in a hundred subtle ways, dominated most European philosophy and science for many centuries; it meant, in some degree, the abandonment of the fashion of thinking of the universe as tied up in neat and orderly parcels, the rejection of rigid categories and absolute antitheses, as inadequate instruments for the description of the complexity and fluidity and individuatedness of things. In other words, the principle of continuity, though itself the product of the extreme of philosophical rationalism, tended in a mild way towards a sort of anti-rationalism, towards a distrust of over-sharp distinctions and over-simple conceptions, towards a sense of certain incommensurability between the richness of reality and the methods of conceptual thought. And in the nineteenth century this same tendency, in vastly more extreme forms, has been far more conspicuously furthered by the influence of the doctrine of evolution. But the idea of continuity as generally held in the time of Buffon had no reference to temporal sequences and by no means involved, in the minds of those who accepted it, any definite belief in the descent of what are commonly called species from other species.[14] If the presupposition of continuous gradations and imperceptible transitions had been explicitly brought to bear upon genetic problems in biology, it would naturally though not necessarily have suggested some sort of theory of descent. But, curious as the fact may appear, the presupposition was ordinarily not brought into connection with genetic problems at all; it was taken in an essentially static sense.

And it seems to have been taken in this sense by Buffon in the introductory discourse in his first volume. A single obscure phrase, which I have already quoted, might be regarded as hinting at the conception of organic evolution, if the general tenor of the essay lent any confirmation to such an interpretation. But nowhere else in this writing is it even remotely suggested that the conception of the continuity of forms involves the conception of the descent of so-called species from one another. It is scarcely conceivable that if Buffon

[14] This fact has often been overlooked by interpreters of eighteenth century writers. When we find such a writer saying that "nature passes from one species to another by gradual and almost imperceptible transitions," it is by no means safe to assume that the phrase contains any reference to genealogical transitions, or that the writer meant by his words to affirm the transformation of species through the summation of slight individual variations. Misapprehension upon this point has caused some eighteenth century authors to be quite undeservedly set down as evolutionists.

had had before his mind so momentous a new idea as that of evolution, he should not have contrived to give a far plainer intimation of it than a single vague remark that imperceptible gradations are found not only in the forms but also in the generations and the successions of every species. At this time, at all events—whatever he may have been later—Buffon was fairly outspoken in the expression of even heterodox hypotheses; it was only subsequently that he was condemned by the Sorbonne, on account of opinions propounded in his "Théorie de la Terre," contained in the same volume as the preliminary discourse. It is significant, moreover, that at this date he saw no hint of any evolutionary significance in the homologies of the vertebrate skeleton; he had as yet learned nothing from comparative anatomy. This is shown in the argument by which he defends his own method of arranging species—a method which wholly ignored anatomical considerations and merely proceeded from the more familiar to the less familiar animals.

> Is it not better to make the dog, which is fissiped, follow (as he does in fact) the horse, which is soliped, rather than have the horse followed by the zebra, which perhaps has nothing in common with the horse except that it is soliped? . . . Does a lion, because it is fissiped, resemble a rat, which is also fissiped, more closely than a horse resembles a dog?[15]

It is probable, then, that in writing the opening discourse of his great work Buffon was innocent of any idea of organic evolution; it is certain that he did not convey that idea in any such way that a reader of his time might be expected to recognize it. Nor did he make any use of the conception of the descent of species in his "Théorie de la Terre," of the same date—where he might naturally have been expected to introduce the doctrine, if he held it; on the contrary he implies (p. 197) the equal antiquity of all species—though he does so in a way which, I confess, might plausibly be taken as ironical. The truth is that when under the influence of the principle of continuity Buffon's mind overshot the problem of the origin of species altogether. There were no such things as species: upon this point he was clear. There was therefore no need of explaining their genesis. As for the further question, how successive generations of offspring are related in form to their forebears, that was a question upon which the principle of continuity had, strictly speaking, nothing to say. That offspring varied somewhat, and usually slightly, from their parents every one knew; to this extent the conformity of the laws of heredity to the law of continuity was a common-place of every-day observation. Beyond this, no definite genetic or embryological consequences seemed necessarily to follow from the maxim *natura non facit saltus*.

The most important thing, however, to remark concerning Buffon's position in his first volume is that it is a position which he speedily

[15] "Hist. Nat.," Vol. I., p. 36.

abandoned, and to which he never returned.[16] Its most characteristic point was the contention that nature knows only individuals and that species are *entia rationis* merely. The most characteristic point of nearly all his subsequent references to the subject is the contention that species are real entities, definable in exact and strictly objective terms, and necessary to take account of in any study of natural history.

This change already was manifest in the second volume, published in the same year as the preliminary discourse (1749). In this volume Buffon propounded his celebrated definition of species, which was destined to have so great an influence upon the biological ideas of the later eighteenth century.

> We should regard two animals as belongng to the same species if, by means of copulation, they can perpetuate themselves and preserve the likeness of the species; and we should regard them as belonging to different species if they are incapable of producing progeny by the same means. Thus the fox will be known to be a different species from the dog, if it proves to be the fact that from the mating of a male and a female of these two kinds of animals no offspring is born; and even if there should result a hybrid offspring, a sort of mule, this would suffice to prove that fox and dog are not of the same species—inasmuch as this mule would be sterile (*ne produirait rien*). For we have assumed that, in order that a species might be constituted, there was necessary a continuous perpetual and unvarying reproduction (*une production continue, perpétuelle, invariable*)—similar, in a word, to that of the other animals.[17]

This language, it will be observed, implies not only that species are real entities, but also that they are constant and invariable entities. The same implication may be found again later in the volume; Buffon thus concludes the exposition of his embryological hypotheses—which embraced a theory of pangenesis:

> There exists, therefore, a living matter, universally distributed through all animal and vegetal substances, which serves alike for their nutrition, their growth and their reproduction. . . . Reproduction takes place only through the same matter's becoming superabundant in the body of the animal or plant. Each part of the body then sends off (*renvoie*) the organic molecules which it can not admit. Each of these particles is absolutely analogous to the part by which it is thrown off, since it was destined for the nourishment of that part. Then, when all the molecules sent off by all the parts of the body unite, they necessarily form a small body similar to the first, since each molecule is similar to the part from which it comes. It is in this way that reproduction takes place in all species. . . . There are, therefore, no preexisting germs, no germs contained within one another *ad infinitum;* but there is an organic matter, always active, always ready to be shaped and assimilated and to produce beings similar to those which receive it. Animal or vegetable species, therefore, can never, of themselves, disappear (*s'épuiser*). So long as any individuals belonging to it

[16] Rádl's account, already quoted, of Buffon's attitude towards transformism and towards the conception of species, is apparently based chiefly upon the first volume. For virtually all of Buffon's views, except his early and quickly repudiated one, Rádl's statement is almost the exact reverse of the truth.

[17] "Hist. Nat.," Vol. II., 1749, p. 10.

subsist, the species will always remain wholly new. It is as much so to-day as it was three thousand years ago.[18]

The reference here is primarily to the continuance rather than the invariability of species. But the latter seems also to be implied; and certainly Buffon does not improve the opportunity to introduce a hint of the doctrine of mutability—as he could hardly have failed to do if he had at this time held that doctrine and had been desirous of propagating it. It must be remembered that these passages also were written before Buffon's opinions had been censured by the Sorbonne.

No account of Buffon's position in the history of biology can be other than misleading which fails to note the decisive significance, for nearly all of his positions from the second volume onward, of the peculiarly Buffonian criterion of identity and diversity of species. Unless this criterion (and the implied distinction between species and varieties, which latter term covers many Linnæan species) be borne in mind, most of the pages in the "Histoire Naturelle" which have an evolutionistic sound are likely to misinterpreted. This is what has happened in a number of the studies of Buffon's relation to evolutionism. The error is especially conspicuously in Samuel Butler's "Evolution Old and New." Butler has devoted nearly one hundred pages to a review of Buffon's utterances on the subject; yet he nowhere lets his reader know that Buffon was the propounder of a new definition of species, which set up a radical distinction between species and varieties, and implied that a species was a definite, objective, "natural" entity. The oversight is not due to any neglect of Buffon's to emphasize and reiterate his definition. He recurs to it frequently in later volumes. His sense of its importance was such that the question of hybridism and the limits of fertility in cross breeding was one of the very few subjects which he can be said to have studied experimentally on his own account. He writes, for example, in 1755:

We do not know whether or not the zebra can breed with the horse or ass; whether the large-tailed Barbary sheep would be fertile if crossed with our own; whether the chamois is not a wild goat; . . . whether the differences between apes are really specific or whether the apes are not like dogs, one species with many different breeds. . . . Our ignorance concerning these questions is almost inevitable, as the experiments which would settle them require more time, care and money than can be spared from the fortune of an ordinary man. I have spent many years in experiments of this kind, and will give my results when I come to speak of mules. But I may as well say at once that I have thrown but little light on the subject and have been for the most part unsuccessful.[19]

[18] "Hist. Nat.," Vol. II., p. 425.

[19] Vol. V., p. 63. The passage is given by Butler, but he shows no sense of its general significance.

(*To be concluded*)

A WORLD-WIDE COLOR LINE

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ONE phase of the declining birth-rate among the white peoples of European stock has become increasingly important now that world interests have begun to override national and continental interests. If mere numbers should turn out to be the determining factor in fixing the balance of world power the European peoples can not hope much longer to retain the hegemony which they have held since the period of wider colonization began. The whites have not themselves become stationary in numbers, but the extension of white influence into regions inhabited by colored races has increased the prospect of a large growth among the latter. Those agencies which have kept down the natural increase of non-European peoples are usually either eliminated or very greatly modified when white rule is established or when white civilization comes to exert a preponderating influence. In Africa, for instance, the slave trade and intertribal wars have been practically abolished in those districts which have come under adequate European control.

To the extent also that the salutary achievements of European civilization have been accommodated to native modes of living, material conditions have been so modified as to furnish an environment theoretically favorable to a greater economy of human life. Because in most instances this influence has been as yet only a casual one, and because many of the race contacts have occurred in regions and under conditions least favorable to good results, the saving of life has not been so marked as it might otherwise have been, but on the whole the influence of white civilization has been a notable factor in population economy among primitive peoples.

There are of course some important exceptions to this rule. If white civilization does not everywhere and always counteract Malthus's "positive checks," misery and vice, it is because the attempt to adjust primitive peoples to a more complex economy is sometimes destructive in itself. Many of the most wholesome conveniences and comforts of the European are disastrous to peoples accustomed to a simpler or at least to a different economy. Nansen claims that the Eskimo of Greenland have been demoralized by the introduction of fire-arms, bread, coffee and cloth as much as by European diseases.[1] Mr. Bryce states that the adoption of European styles of housing and clothing, those pet items in the program of the militant philanthropist, has literally decimated the natives of Hawaii since Captain Cook's time.[2]

[1] Nansen, "Eskimo Life," pp. 328–331.

[2] Bryce, "The Relations of the Advanced and Backward Races of Mankind," p. 11.

To these influences should be added the diseases, before unknown, which the whites have carried with them. Tuberculosis, small-pox, syphilis and alcoholism have proved peculiarly destructive to primitive peoples accustomed to a mode of life which brings the effect of such diseases to a maximum. Until proper medical service and adequate sanitary safeguards are secured, this heavy penalty for the fruits of civilization must continue to be paid. The change to a settled, orderly mode of living and to a new food economy may also often bring about a physical deterioration as baneful as specific diseases.

European colonization in regions occupied by backward races often results in the violent destruction of native populations in the struggle for territory. The Dutch settlers in South Africa are said to have regarded "shooting off the black stuff" as their first task in fitting the land for occupation. Whatever the government may have intended, it is certain that the English colonists in Australia have in many instances deliberately slaughtered the blacks on the pretext of safety. Writing of conditions as they existed thirty years ago, Carl Lumholtz says:

> There are instances where the young men of the station have employed the Sunday in hunting the blacks, not only for some definite purpose, but also for the sake of the sport; the blacks have been killed by poison. A squatter at Long Lagoon in the interior of Queensland achieved notoriety by laying strychnine for the blacks, and thus taking the life of a large number in a single day. . . . The result of this is that in the frontier districts there is still being waged a war of extermination between the two races. Any savage discovered by the white man runs the risk of being shot. Poison was laid in the way of the blacks once while I was in Queensland.[8]

In certain instances like Tasmania and Cuba, European colonization has led to the complete extinction of the aboriginal population as a separate group, and in other instances, like those of the Maoris of New Zealand and the Hottentots, the native population has been very greatly depleted. Most of these disastrous results have come to peoples, generally blacks, in the lowest stages of culture. Where the aborigines are more advanced and hence more pliable they have usually profited by contact with Europeans. As a consequence several colored races are now enjoying considerable prosperity, due to the removal of the worst checks to their growth. The negroid peoples exhibit an amazing power of multiplication when protected from destructive forces. Negrophobe critics are wont to go so far as to hold that this is the sole important capacity which the blacks possess. The race is taunted with being by nature and capacity *proletarii* in the most primitive sense of the term —mere breeders.

While the yellow races are not so characteristically prolific as the blacks, they have, in several conspicuous instances, emerged on the modern field not only with a more elaborate culture, but with a denser

[8] Lumholtz, "Among Cannibals," pp. 346–347.

population within their natural habitats. Roughly speaking, eastern Asia is already peopled almost to the limit under present conditions, while tropical Africa is but sparsely populated in proportion to its capacity. Under favorable conditions of economic efficiency tropical Africa would be the home of nearly a billion blacks. Taken together, and allowing for a normal growth, these two ethnic groups may possibly increase in numbers until they shall cause the whites of Europe and America to dwindle into insignificance by comparison.

This is the thesis of a recent significant book by B. L. Putnam Weale, an authority on far eastern politics.[4] The peril of white supremacy arises, Weale believes, not alone from the growing balance of numbers in favor of the colored, great as that is likely to prove, but from the fact that the colored races are beginning to acquire and will continue to gain a distinct race consciousness and a sense of race solidarity. And just as the narrow interests of the little Greek lands were supplanted by the wider outlook of Alexander's empire, as the peninsular civilization of republican Rome was swallowed up in the world dominion of the imperial period, so the continental system of modern Europe is being swept into the whirl of world-wide interests. In this great historical change the ethnic element, or, more specifically, color, is to be the militant factor. With the increase of intelligence the aggressiveness of the colored races will augment and they will begin to take conscious advantage of their weight of numbers. A readjustment of power must follow as fast as the colored races become efficient in the arts that make for group self-assertion. For, says Weale:

> Real frontiers—real barriers to the swaying to and fro of peoples—are no longer rivers or mountains or seas or any of those physical features still referred to in the geography books. These are only the frontiers of savages; the real frontiers of civilization are formed by masses of men distributed in proper density, highly civilized, irrevocably locked to the soil by their history and their culture, and sufficiently warlike to make their physical boundaries respected should wanton aggression menace them. . . . A deep instinct will continue to push men to substitute for the purely political demarcations which have come down from other days a new class which may be called racial demarcations. That such demarcations are necessarily blurred is no matter; this only adds one more difficulty to a question which force may attempt to solve. It is this knowledge—that racial instinct and racial pride ignore political boundaries—which is the nightmare of statesmen.[5]

The colored already outnumber the whites of the world nearly two to one, and this proportion is likely to increase rather than diminish in the immediate future. Weale estimates that by the year 2000 China will have eight hundred million population and Japan one hundred and twenty to one hundred and forty million. As race consciousness grows more pronounced war must constantly occur as the colored races be-

[4] "The Conflict of Color," London, 1910. Weale is the pseudonym of Mr. B. L. Simpson.

[5] *Ibid.*, pp. 90–91.

come stronger in offensive ability and attempt to win back piecemeal what they have lost in the past while still "undrilled." "That they must become at least masters of their own houses can not any longer be doubted." [6]

Against this alarmist view two objections may properly be offered on the score of population increase. In the first place, as the colored races approach the standard of the white civilization, the same influences which have reduced white fecundity will increasingly operate among them. As has already been shown, improved modes of living are already making possible a greater population economy among the colored, and the acquisition of still higher standards will lower the birth-rate to a point consistent with these better standards of living. Secondly, it is not at all true that the expansion of the white race has now reached its final geographical limits. Not to assume that certain elevated districts within the tropics may in time be open to white colonization, there are still vast areas in Siberia, South America, South Africa and Australasia so sparsely settled as to be practically uninhabited. It is therefore nearer the truth to say that the habitat of the colored races is now fixed beyond the possibility of notable change except by sporadic migrations, while the greater regions at present sparsely peopled are within the white sphere of influence.[7]

COLORED

	Per Square Mile.
China	266
Japan	320
British India	211
Java	600

WHITE

	Per Square Mile.
United States	25.6
Canada	1.48
Argentina	5.4
Siberia	1.4
Australia	1.5
Cape Colony	8.7
Transvaal	10.0

That there already exists, since the rise of Japan, a well-marked sense of race solidarity among the yellow peoples of eastern Asia need

[6] Estimating the total population of the world at 1,705,000,000, Weale makes the division by color as follows:

Whites	566,000,000
Mixed whites	40,000,000
Absolute yellow, brown and black	1,099,000,000

Of the whites 453,500,000 are assigned to Europe, and of the colored 947,000,000 belong to Asia and 140,000,000 to Africa (p. 111).

[7] The density of population in certain of the greater habitable areas peopled by the whites and by the colored outside of Europe shows some significant contrasts:

not be disputed, but that this will long remain the basis of eastern Asiatic politics is not certain, or even probable. The Japanese alliance with England shows how feeble are ethnic as compared with purely national interests in international relations. The negroid peoples, although they have made little progress towards a distinct race consciousness, are beginning to show glimmerings of a sense of ethnic unity, or at least a consciousness of separateness from the whites. After the Russo-Japanese war a vague rumor that a white race somewhere had been beaten in war by a colored people filtered into very remote portions of Africa. During the Boer war news of British defeats spread with incredible rapidity among the blacks and was everywhere received with exultation. Among the blacks of South Africa the colored churches are found to very soon cast off their alliance with white churches and to insist on separate ecclesiastical organization. This so-called "Ethiopian" movement, it is interesting to note, is fostered by the negro churches in America, with which in several cases definite alliances have been made.[8]

Weale's alarm call to the white race is based on the assumption that the whites as whites are likely to be faced by the colored races in solid array. He calls attention to the fact that the European nations are disunited and can not act harmoniously in either Asia or Africa, and that they will be so hopelessly outnumbered in the near future that even united action would leave their position hazardous. Now it may be possible that we are to see a great development of geo-politics, so that the cry "Asia for Asiatics," or "Africa for Africans," will unite the peoples of those continents in solid mass. But geo-politics must not be confused with ethnic politics; and if considerable independent white groups should arise in Asia or Africa it is probable that they would be among the foremost in resenting European domination. Nor is it likely that the yellow and black races will ever find common ground of union among themselves and against the whites, just as it is unlikely that the white peoples will always remain disunited in the face of a real peril. To assume such a danger is to suppose that the ethnic element will continue to constitute the important factor in world politics that it now does. It is much more reasonable to believe that economic and cultural interests will ultimately supplant purely ethnic interests as the groundwork of world contacts.

The real kernel of the color problem, then, is likely to continue to be what it is at present, the question of social contact among peoples of different racial stocks, and particularly of different cultural levels, living together within given political areas, rather than a struggle of independent racial masses against each other. In America there is a wide-spread belief that our color problem is one peculiar to

[8] See the report of the South African Native Races Committee entitled "The South African Natives," Ch. VII.

ourselves. As a matter of fact, the race struggle covers the whole world, wherever whites and blacks are brought together under common political and social forms. It is the struggle of a highly differentiated, efficient civilization with one more simple and primitive. This struggle results from the differing powers of adaptation of the two races. Racial characteristics are the accompaniments rather than the cause of lack of adjustment.

Since the elements of the problem are simple and fundamental and since they are everywhere essentially the same, it is to be expected that the color struggle should follow similar lines in various parts of the world. The antipathy between the whites and Indians in America from the earliest period of colonization to the present, the very terms in which this antipathy was expressed and the methods of conflict on each side, have been duplicated in the struggle between the English colonists and the natives of Australia, Tasmania and New Zealand. And at the present moment the political and social elements of the race problem in the southern States of America are almost identical with those in the South African colonies.

It has been the misfortune of white civilization in its contact with the colored races in America, Africa and Australasia that both its worst products and its least desirable representatives were the ones first in the field. This has been an important factor in shaping the early relations of the races. It is the rover, the outlaw and the irresponsible trader who come first, and it is too often the contraband goods of civilization that they carry. It has been the rougher type of white also who has intermarried with native women and become the father of a hybrid progeny. Curiously enough, it is among this rougher class of whites that the worst type of race animosity exists. Where the cultural rank has been more nearly equal and where the contact has been of the organized rather than sporadic type, the mingling of the races has generally been accompanied by little confusion or social disintegration.

It goes without saying that there is a varying degree of adaptability and fusing power among the different branches of the white race in their relations with backward peoples. The Latin peoples in Europe have shown peculiar capacity for successful inter-marriage with tropic races. Spaniards have crossed with fair success with both Indians and negroes in America and with Malays in the Philippines, as have the Portuguese with the two former types in Brazil. Undoubtedly the Catholic Latin peoples have shown peculiar capacity for merging with colored peoples and manifest less color prejudice than do the Protestant Teutons. This is due, no doubt, in part to physical facts, but a more important factor is the insistence of the Roman Catholic Church on the solidarity of the world's peoples and its deprecation of race prejudice. In the Spanish and French West Indies there is a greater proportion of mixed marriages

than in the British West Indies and there are fewer evidences of social friction.

While the antipathy of white toward black is the most pronounced phase of color conflict, prejudice against the blacks is not confined to Europeans and Americans. The Chinese, the most cosmopolitan of peoples, sometimes exhibit a striking aversion to taking black wives or concubines, but manifest no particular aversion to the native women of Java or Borneo. East Indian laborers imported into the British West Indies and British Guiana have generally refused all intercourse with negro women. The American Indians have sometimes interbred with blacks, but in British Guiana they are reported to despise the negroes and to have little intercourse with them.[9]

It is sometimes asserted that a rigid enforcement of the color line in the tropics would leave the two races isolated in an intractable antipathy. Sir Sidney Olivier, governor of Jamaica, has argued from this that a middle class of mixed stock serves as a useful buffer between white and black. He says:

> Where, therefore, we have created and are developing a community of diverse races, I can not, in the light of British West Indian conditions, admit that interbreeding is necessarily an evil. I think, rather, that where we have such a community we had better make up our minds not only not to despise the offspring of illicit interbreeding that invariably takes place in such conditions, but make our account for a certain amount of legitimate and honorable interbreeding and to look upon it, not as an evil, but as an advantage.[10]

But such interbreeding, Sir Sidney maintains, should invariably come about by the marriage of white men with colored women. There is a good biological reason for this, but the primary consideration is the racial welfare of the whites. Whatever the good qualities of the negro, and Sir Sidney sees more of them than most of his fellow whites, he nevertheless thinks that

> the white races are now in fact by far the further advanced in effectual human development, and it would be expedient on this account alone that their maternity should be economized to the utmost. A woman may be the mother of a limited number of children and our estimate of the number advisable is contracting; it is bad natural economy, and instinct very potently opposes it, to breed backwards from her. There is no such reason against the begetting of children by white men in countries where, if they are to breed at all, it must be with women of colored or mixed race. The offspring of such breeding, whether legitimate or illegitimate, is, from the point of view of efficiency, an acquisition to the community and, under favorable conditions, an advance on the pure-bred African.[11]

A mixed stock, however, while it may lessen the actual clash between the two extreme types in a community, does not necessarily diminish the totality of race antagonism, and may augment it. For the hybrid, instead

[9] Johnston, "The Negro in the New World," pp. 331, 332 and 334.
[10] Olivier, "White Capital and Colored Labor," pp. 39–40.
[11] *Ibid.*, pp. 37 38.

of commanding the confidence of both parent stocks, usually himself becomes the object of animosity on the part of both, and this is an added danger to social peace. Ostracized by both races, he is particularly hateful to the more backward type. Mixed breeds usually possess greater mental capacity than the pure blacks and are the victims of the latter's jealousy.[12] This is in harmony with the familiar social law that in a given society made up of hostile classes it is the nearest, and particularly that next above in the social scale, which is most cordially hated. Jealousy of hybrids is due chiefly to two causes. They are, except in the United States, more freely admitted to social privileges, and it is with them that the dominant race is more likely to contract marriage. In the United States, where any appreciable intermixture of blood exists, the mongrels are enumerated as negroes, while in nearly all the other countries mixed breeds constitute a separate and often a privileged class.

To characterize the negroes merely as a passive race, as is often done, does not fully cover the situation. It is more nearly correct to describe them as pliable and imitative. Ability to bend and adapt has proved the negro's salvation in the supreme test of contact with complex and often rigid white institutions. In marked contrast stands the American Indian whose "grand refusal" has been his undoing. Not only has the negro of the new world survived transplanting, but he has everywhere taken on the cultural tone of the particular white group with which he has been brought in contact. In Spanish America he has acquired the taste in dress and the pride bearing of the Castilian. In Haiti he is essentially French and in Brazil Portuguese. The impress of France is still on the negroes of Louisiana and the Jamaican negro is unmistakably British.

In other words, the negro reflects by imitation the civilization of the society in which he lives. His character in any mixed society depends largely on the social standards which others set. Originally brought into touch with European civilization without any fixed cultural equipment of his own, he develops in social capacity along the lines of least resistance, reacting to such stimuli as the social environment offers. But while lacking in positive cultural achievement he possesses certain well-developed temperamental traits which enable him to fit into some social environments better than others. He is sensuous, and his esthetic nature is richer on some sides than that of the north European. It can hardly be questioned that the Latin temperament is better adapted to harmonize with the negro than is the less volatile Teuton.[13] Just as the American

[12] See Prichard, "Where Black Rules White: Haiti," p. 280; also Kirke, "Twenty-five Years in British Guiana," pp. 260–262.

[13] Oliver asserts that the negro is naturally more courteous than the lower classes of northern Europe, and he is convinced that the insolence of the American negro is due in large measure to the bad manners and unwarranted pretensions of the whites. "White Capital and Colored Labor," pp. 46, 48.

negro feels an instinctive admiration for southern white people, in preference to unemotional northerners, so the race has in the course of generations reacted more spontaneously, and perhaps more wholesomely, to the vivacious Latin temperament than to the sterner Teuton type. The smaller degree of race friction in the Latin colonies may point to a possible modification of world policy in the white man's growing problem of dealing with black races in Africa and Australasia.[14]

This tendency of the negro to take on the psychic tone of the dominant culture may have far-reaching results in Africa itself. Weale is convinced that if the African negro shall be Mohammedanized the fate of the white man's empire in that continent will be sealed. From the Arabs the negro would acquire an aggressive, war-like spirit that would ultimately lead to his mastery of his own continent. If, on the other hand, the Africans are christianized they will remain docile. But, as already noted, the negro temperament is little adapted to aggressiveness or independent activity. It is therefore more probable that he will develop in civilization, if he develops at all, on the lines of the European peoples who are pressing on the more remote portions of Africa with ever-increasing persistence.

Wherever the blacks are massed in undisturbed possession of the soil, their contact with the whites is in the nature of independent group antagonism. In tropical Africa the true negro is at home, and, so far as can now be foreseen, the white man can rule only as an outsider without constituting any appreciable element in the social population. But on the fringes of the continent the situation is very similar to that in the United States, where a ruling race is settled upon the same soil and is capable of self-perpetuation. But even in temperate South Africa it is possible that large political units, wholly black, may survive. The South African black, except in Cape Colony, is not at present granted equal political rights, but if he continues to progress in intelligence as he has recently done his demand for political and social equality must become exceedingly strong, as it has in the United States; and the struggle for equality will of itself be a means of developing a fixed sense of race separateness which must long make the color question a sore spot in South African politics.

In the Australian commonwealth the color problem exhibits a most peculiar and interesting phase. The aboriginal inhabitants scarcely figure in the question at all. There can, for the present, be little idea of their active participation in organized social interests, both by reason of their small numbers and because of their absolute lack of capacity. It

[14] Sir H. H. Johnston points out that the hold which the French secured on the negroes of the Windward Island and of Dominica during the period of their occupancy was deeper than that which the English have been able to acquire during the period of British rule. "The Negro in the New World," pp. 233–234 and 306–309.

is the colored immigrant, whether black, brown or yellow, who furnishes the problem. This new commonwealth, with a native black population regarded as negligible, has deliberately set out to develop an exclusively white civilization on Australian soil, even at the expense of a dearth of labor force. So powerful has the "White Australia" movement become that stringent exclusion laws have been passed by the commonwealth parliament denying admission to all non-British immigrants unable to pass fixed educational tests, and providing for the deportation of numerous colored laborers already present on contract. How passionate the "White Australia" idea is, and how deeply it deplores the evils of race mixture in the rest of the world, is manifest in the words of its most scholarly exponent, Professor Charles H. Pearson:

> Australia is an unexampled instance of a great continent that has been left for the first civilized people that found it to take and occupy. The natives have died out as we approached; there have been no complications with foreign powers; and the climate of the South is magnificent. . . . We are guarding the last part of the earth, in which the white races can live and increase freely, for the higher civilization. We are denying the yellow race nothing but what it can find in the home of its birth, or in countries like the Indian Archipelago, where the white man can never live except as an exotic.[15]

Such a policy of white segregation, if it were sound, would be an example of the thing which nations ought to undertake more often than they do. It represents a deliberate choice of ends planned for long in advance, and it is an admirable case of what Lester F. Ward calls "social telesis." But this paticular policy happens to be one which is open to serious question. It never has succeeded, nor is it likely to prosper in Australia, because the aggregation and composition of populations are governed by laws of selective fitness which are stronger than statutes. Certain areas in various parts of the world are almost certainly destined to belong primarily to the whites, as certain districts of Africa and of the United States may come to be recognized as the special habitat of negroes, but the selection must come in the first place from natural fitness rather than law, and the area is never likely to be continental in extent.

The island of Cuba exhibits the curious spectacle of a tropical land which is peculiarly fitted to be the home of a colored race, but which is for the time being swinging towards a decisive white majority. After 1898 it seemed that Cuba was to follow the steps of Haiti and become a black republic, but immediately after the war of liberation there set in

[15] Pearson, "National Life and Character," pp. 16–17. For details of the "White Australia" movement, see Scholefield, "The White Peril in Australasia," in the *Nineteenth Century* for August, 1905; and Law and Gill, "A White Australia: What it Means," in the same periodical for January, 1904. The law of 1901 excluding colored labor was entitled "The Pacific Islanders Act." The final limit for deporting the contract laborers was fixed for December 31, 1906. To prevent the destruction of the sugar industry in Queensland a bounty is offered on sugar grown by white labor.

an active and steady immigration of Spanish peasants which in ten years has amounted to 128,000.[16] Gradually overborne by numbers, the negroes are beginning to segregate, and in 1908 a party of color was formed. While there is as yet no definite color caste in social life, the supplanting of Spanish influence by American ideas will doubtless gradually assimilate conditions in Cuba to those of the neighboring states of America.

In the last analysis color prejudice is based on cultural difference more than on the degree of pigmentation. Because extremes of physical difference do actually in large measure accompany difference in culture rank, the most radical race antagonisms are those between the extreme whites and the extreme blacks. A black skin is everywhere associated in thought with cultural inferiority. Back of this may lie a subconscious suggestion of the historical fact that the negroid races have achieved few of the cultural values that are to the white man the marks of superior mental and social efficiency. To the extent that the blacks live down this stigma of cultural inefficiency prejudice against them will lose its force. There are abundant evidences of color aversion on the part of the white towards the yellow, brown and red races, but it nowhere reaches the intensity of that directed against the blacks, nor is it of sufficient depth to constitute a fundamental social problem.

Speaking particularly of race antagonism in South Africa, Mr. Bryce says:

> The sense of his superior intelligence and energy produces in the European a sort of tyrannous spirit which will not condescend to argue with the native, but overbears him by sheer force and is prone to resort to physical coercion. Even just men, who in theory have the deepest respect for human rights, are apt to be carried away by this consciousness of superior strength, and to become despotic if not harsh. And the tendency to race enmity seems to lie very deep in human nature. Perhaps it is a survival from the times when each race could maintain itself only by slaughtering its rivals.[17]

It is therefore by narrowing the gap between the actual cultural status of the races that the worst aspects of race animosity are eliminated. Whether, as Boas and Ward hold, the total mental capacity of all races is essentially equal, is not here the question. Achievement of any valid kind, whether by individuals or by racial groups, is bound ultimately to command respect. World contacts are rapidly increasing and a higher degree of intergroup cooperation is making possible a wide diffusion and sharing of the achievements of each of the great racial groups. When this process shall have gone far enough much of the asperity which has characterized the periods of isolation will be materially softened.

[16] "Censo de la República de Cuba," 1907, pp. 59–66; see also Johnston, "The Negro in the New World," p. 60. The census of 1907 shows that in a total popuulation of 2,048,980 the colored number 608,967, or 29.7 per cent. The unmixed negroes number 242,382.

[17] Bryce, "Impressions of South Africa," p. 366.

It is an unquestionable fact that the yellow as well as the negroid peoples possess many desirable qualities in which the whites are deficient. From this it has been argued that it would be advantageous if all races were blended into a universal type embodying the excellences of each. But scientific breeders have long ago demonstrated that the most desirable results are secured by specializing types rather than by merging them. The perfection of individual qualities insures a high degree of general efficiency in case those qualities can be coordinated in a systematic organization. This is particularly true of human types. The doctrine of racial Darwinism no longer implies a struggle in which the defeated type is exterminated. Under conditions prevailing in modern civilized association it implies rather an application of the selective principle through a combination of competition and cooperation, by which the superior qualities of each race are sifted out and brought to efficiency. It implies also a rough sort of interracial division of labor.

A group of negro leaders in America have advocated the principle of a "group economy" for the colored people of the south, and the idea is capable of a wider application to the great racial groups of the world. In a world of free exchange and intergroup cooperation it is absurd to suppose that the white race can get the benefit of whatever is useful in the tropics, for instance, only by conquest and colonization. Perhaps it is true that the tropical peoples will become efficient only through the influence of organized white leadership, but Mr. Kidd's plausible plea that the white race ought to master and hold the tropics "in trust for civilization" is an empty phrase unless it means a real overlordship. The question inevitably arises, "Whose civilization?" For when the colored races shall have developed an adequate race consciousness it is inevitable that they should seek to devise their own institutions according to their needs, and from the point of view of world interest it is desirable that they do so.

The color line is evidence of an attempt, based on instinctive choice, to preserve those distinctive values which a racial group has come to regard as of the highest moment to itself. Although sometimes based on a blind prejudice surviving from the primal instincts of periods of isolated savagery, it invariably, in its better phases, has in it the core of a sound scientific truth, which is that specialization is the law of efficiency. The fact that it is always the lighter race that puts the taboo on the colored, and that the latter is everywhere eager to mix with the whites, is only an evidence of the general trend of choice towards the higher efficiency of the white race.

THE CROSSING OF THE RACES

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A Study of the General Principles governing the Successful Intermixture of Different Peoples, with special Reference to the Question of Immigration into the United States.

THE question of racial amalgamation is almost as old as the race itself. For, not only the earliest traditions, but also the most ancient relics bear witness to the fact that extensive intermarriage of races had been brought about through commerce and war long before history had begun to unravel the tangled skein of man's wanderings.

The crossing between different tribes, which was commenced in prehistoric times, has been continued into our own era with ever increasing speed and complicity of results. For man has always been a migratory animal, and the improved changes in means of transportation and the ever-widening fields of commerce have increased rather than diminished this inborn tendency.

Looking over the world at large, and throughout all time, we see that the results of racial intermarriage have been exceedingly variable. Sometimes it has produced a better race. This is especially true when the crossing has been between different but closely allied stocks. The Englishman who has resulted from the commingling of so many Teutonic tribes with the native Briton and Celt, and the composite molded and directed by Roman culture, is perhaps the very best example of a good result from extensive crossing. Likewise the cross which has taken place in Ecuador, Mexico and Peru has produced a race not altogether hopeless so far as the future is concerned; for, however much it may have hurt the Spaniard, it certainly has improved the Indian immeasurably. It is not so much a question of the *possibility* of producing a vigorous cross race under favorable conditions, as it is a question of whether such a cross is, in itself, a *desirable* thing.

There are those who profess to believe that the incoming hordes of southern Europeans and the Alpine races will never mix their blood with us to any appreciable extent, and will always remain foreign in race as well as in ideals. Judged in the light of history, such an opinion is without firm foundation. It is not conceivable that the modern Greek, who is himself such a mixture of Serbo-groation, Slav and ancient Greek stock, can have any irrevocably inborn tendencies which will prevent him from eventually mating with our own people if given the

opportunity. The German will marry any woman of any white race. The Italian will do the same. The Alpine races have intermarried to the north and south of them until their mental traits shade off almost imperceptibly into those of the German and Italian. As a general rule, marriage between different branches of the white races is not governed by laws essentially different from those governing individuals of the same branch. It is chiefly a question of proximity of the sexes and the lapse of sufficient time to make the mutual desires mutually understood.

The vital question is, whether this inevitable amalgamation is worth the fostering care and regulation of our government. The answer to this question depends altogether upon what will be the results of this immigrant blood upon our own individual selves and upon our social and political institutions.

In regard to the influence upon the individual physical type, we often hear it said that we are becoming a smaller and a darker race; that our average stature is less than it used to be, and that we are becoming dark eyed and dark haired, instead of the race of tall blonde we once were; and there is a tendency to blame the immigration of the last half century for this alleged change in physical characteristics. If such a change is taking place, it should be attributed to the influence of our climate rather than to the effect of blood admixture. The stature and complexion of a people seem to be determined, in the long run, more by the locality and climate in which they live than by any other influences, although it takes many generations for that physical type to be finally evolved which is best fitted to the climatic conditions of its particular locality. Once evolved, the type remains fairly constant for the given region. Judging the future by the past, we should not expect the tall blonds of northwestern Europe to permanently survive in the United States. There is scarcely a trace of the physical traits of the conquering northern hordes left upon the general mass of the population of Italy or the Alpine regions of Europe. The colony of Swedes which settled along the Delaware in our own country have entirely disappeared. The Scandinavian, according to Dr. Karlsen, who has made the subject a matter of special study, rapidly deteriorate, physically and mentally, under the changed climatic conditions which he encounters in his new home in the northwest of our own country, and no less an authority than Woodruff, believes that he will soon die out in the United States unless active measures are taken to offset the baneful influences of a climate to which he is temperamentally and physically unsuited.

In evolving the type of man physically fitted to best survive in a given locality, nature seems to work according to some mysterious laws entirely beyond human control. This is exemplified in the population of modern Egypt, where the mass of the people as represented by the villagers along the Nile and in the country districts, conform almost exactly in physical appearance to the colored portraits of the ancient

Egyptians on the walls of the tombs of the kings of Thebes. In other words, 4,000 years of changing religions, ever-shifting political conditions, and the inroads of commerce and war with their continual introduction of alien blood have not served to materially alter that physical type, which, during the countless ages of prehistoric time, had been gradually evolved as best adapted to the climatic conditions of the valley of the Nile. It may then be concluded that the influence of immigration upon our physical type will, in the long run, be nil. *That type of man best adapted physically to the climate and soil will, in the point of numbers, eventually predominate in spite of all restrictive legislation or man-made laws of any kind.*

When we come to consider the question of the influence of racial amalgamation upon our *habits* of *thought,* upon *our morals,* and upon *our institutions*—upon our spiritual selves, we are confronted with a much graver problem, and one over which we have at least some little power of control. This is really the serious problem which we have to solve, for, after all, it is not so much difference of blood relations that produces enmity among the component peoples of a nation, as it is the difference of political and social ideals, and history is replete with instances where nations have lost their own peculiar form of civilization and political institutions on account of overwhelming alien influence. That the influence of the alien in the United States is enormous, and that it is becoming yearly more and more important, is an almost self-evident proposition.

In order to arrive at a fairly intelligent opinion as to whether or not this influx of foreign thought and social habit will ever change sufficiently to conform to our own standards, we should study the history of the nations from which it comes, and whose ideals it has already helped to form. Is there anything in the past history of the countries from which our immigrants are now being chiefly recruited to justify the belief that they will eventually sympathize with our political institutions and with those Anglo-Saxon habits of thought which we must insist upon as necessary to good citizenship in a great republic? A brief study of the leading alien type will demonstrate the principle upon which the research necessary to answer this question should be conducted.

Let us first consider the case of the Italian. Here we may be tempted to at once pass an unfavorable opinion on the ground that he is, by virtue of previous training and habits of thought, at entire variance with republican ideals. Such a judgment will be hasty and hardly warranted by the premises. When we remember what the Italian has accomplished for himself at home since 1820, when the first real agitation for a free and united Italy may have been said to have commenced, it should encourage us in the belief that he is capable of sustained and intelligent efforts for the common good.

Whereas Italy was once a conglomeration of petty states and absolute monarchies, torn by warring factors, and her people steeped in universal illiteracy, she now, through her own efforts, under the intelligent leadership of children of her own soil, has become a constitutional monarchy with the real power legally invested in the people where it by right belongs. Through his prime minister, the king is responnsible to the chamber of deputies, which corresponds to our lower house, and are elected by the people at large.

The senate is probably as truly representative as our own, being elected by the king from the ranks of the ex-deputies, the nobility, large taxpayers and representative men of affairs.

When we consider that for fifty years preceding her final unification and freedom Italy was in an almost constant turmoil of political agitation and war, it is remarkable what advances her people have made in the thirty-nine years since the accomplishment of her great ambition. Although she still ranks high among the illiterate, she has taken great strides to overcome that evil. An education law compelling the attendannce at school between the ages of six and nine, and the teaching of illiterate soldiers, although they may not as yet have accomplished great things, show that her heart is right, and that time will fast remedy the evils which the exigencies of her struggle for existence have practically forced upon her.

The study of the Italian in the Argentine ought to give us an inkling of his possibilities when given an opportunity. This republic is modeled on lines almost exactly after our own, and, all things considered, should rank as a successful experiment in self government. Its people are happy. It enjoys a high degree of culture. Its cities are modern and well governed, and its commerce is ever increasing in dignity and volume. Now, relative to its whole population, Argentine has the largest number of Italian immigrants of any country in the world. In 1895 the total population was about 4,000,000, and one third of this was foreign born. Of this foreign born population 500,000 were Italians. This enormous Italian influence still holds its own, for since 1895 it has kept up almost constantly, and for the whole period of time elapsed since she became a republic in 1853 nearly half her foreign born population has been contributed by Italy.

We should not allow the evil deeds of certain bands of outlaws, and the criminal tendencies of certain of the lower classes to blind our vision to the great things accomplished by the Italian as a nation. Viewed in the light of her past history and her rapid advances of the present day, she promises well, and it is a fair prophecy that in our own country the future citizen of Italian forebears will only be distinguished from the general average by means of his family name remaining as a sign to indicate his original ancestry.

The possibilities of the Slav, and his aptitude for conformity to the

ideals of western civilization, can not be adequately treated without an exhaustive review of the history of the nations of eastern Europe. However, a short résumé of Polish characteristics will suffice to give an idea of the type of the race and result which may be expected from the great wave of Slavic immigration now sweeping over us.

For the two hundred years succeeding the close of the fourteenth century, Poland was the leading power of eastern Europe. Her 20,000 square miles was the seat of what was, to all intents, a vast republic, for, though her elective king was responsible only to her nobility, this nobility was so large and so accessible and eager to maintain the political equality of all its own members, that the constitution, though it conferred rights only upon the privileged classes, carried out in reality the idea of almost unlimited freedom for the individuals of that class. Had this very numerous nobility of freedom born a still larger proportion to the total population, the self government of the nation would have been an accomplished fact, for the ideas of political reform and the extension of privileges to all classes were already beginning to make themselves felt when Poland was caught between the upper and nether mill stones of foreign tyranny, and her national identity crushed out forever by the treachery of Prussia and the soldiers of the Russian throne. Since the last partition of Poland in 1795, her people have not been given the chance to exercise the capacity for self government which they had undoubtedly developed to a high point when overtaken by the series of misfortunes which resulted in the loss of national identity. There are many reasons to think that this capacity is not wholly dead, but only lies dormant, awaiting the propitious changes of fortune. At the same time it must be conceded that the Pole possesses, in common with all Slavs, a peculiar combination of eastern and western ideals that makes his fitting into an Anglo-Saxon civilization a problem of great complexity. For, while he loves political freedom almost to the point of insanity, he is easily caught by the glitter and pomp of a throne. Confiding by nature, the mere promise of the unscrupulous Napoleon was sufficient to make him offer up his life upon many a bloody battle field.

As the Poles are, individually, poor business men, easily imposed upon by the commercially minded Hebrew, to whom the generosity of a political asylum was time and again extended when he was driven and harried from almost every other country in Europe, so are they, in the aggregate, poor political economists, and have thus always been worsted in the fields of diplomacy as well as in trade. Whereas they possess the greatest intellectual gifts, being almost universal linguists, and contributing great names to literature and science, they are apt to be versatile rather than profound, and are prone to waste their efforts in unpractical fields of endeavor. Though courteous and brave, their love of individual freedom is sometimes carried to the point of anarchy, and

when guided by unscrupulous leaders this tendency often shows itself in riotous uprisings which are entirely out of proportion to the grievances against which they are directed. However, the Slav has one redeeming feature which, if properly utilized, might, in time, offset these undesirable characteristics. This feature might properly be called his *great willingness to learn new things.* He is not clannish. He has no innate deep-grounded instinct against getting acquainted. Naturally diffident and retiring on account of long centuries of class distinction, he is not prone to make the first advances, and consequently, if left to himself, he will tend to congregate with his kind. But his children quickly make friends with ours, and the foreign parents never discourage this tendency. Considering the short time that he has been with us, and his ignorance of our language, he has shown a marked tendency to amalgamate, and so long as we allow him to come at all, we should encourage this tendency, for although very different from us in his natural habit of thoughts and intellectual gifts, these differences are not of a kind that tend to produce moral or intellectual deterioration, and from a physical standpoint he will add to, rather than subtract from, the efficiency of our race.

The Slav and the Hun have been associated together so long in Europe, and their immigration to this country has been, in each case, extended over practically the same period of time, that it is quite the natural thing to consider them both together when making a study of their special race characteristics and possibilities of amalgamation. However, it is more a community of interests and political institutions than it is a racial identity that makes us class them together and speak of the Slavish and Hungarian immigrant as practically of the same kind. In reality these two stocks are essentially different and have shown rather wide differences in their respective abilities to adopt the ways of western civilization. The true Hungarians or Magyars are a Mongolian or Turanian stock. They left their Asiatic home about 1,000 years ago and descended upon Europe as a barbarous horde that for fifty years struck terror into the hearts of the neighboring inhabitants of Germany and Italy. Finally the Germans conquered them and they were almost at once forced to accept the alternative of western civilization or racial extermination. They chose the former, and immediately they demonstrated a high degree of adaptability to democratic political institutions. They united with the other kingdoms of eastern Europe to stay the march of the Ottoman Turks, and come in for a full share of credit in the series of events which finally resulted in the naval battle of Lepanto in 1571, when the long struggle between the two opposing religions for the possession of Europe and the consequent mastery of the world was forever settled in favor of christianity. Thus we see that the Hungarians not only adapted themselves to western ideals, conforming to the manners and customs and religion of the

people about them, but they became the greatest active exponents of these ideals, and for over 500 years they were the main defence of Christian Europe against the Turkish tribes of Asia that followed closely in their footsteps.

Manifestly the western civilization thus upheld by the Asiatic Hungarian in eastern Europe is different in many ways from Anglo-Saxon or Germanic culture. Whereas a high degree of individual liberty has been the aim of both, the one has succeeded in attaining its goal by making self sacrifices and compromises for the common good, while the other has not yet attained complete freedom, largely because of a failure to understand the essential differences between liberty and license. In Hungary to-day we have a sad example of this seeming lack of ability to forget individual differences for the common good. In the eastern half of the monarchy, a Hungarian minority holds the non-Magyar races in just such political serfdom as they themselves were subjected to before 1866, when the Prussians established the preeminence of Germany in Austria. And yet, in all fairness, we must not too hastily assume that the Teutonic races have a monopoly of that political unselfishness which makes self government possible.

The Pole might justly say that the rebellion of the barons and the Magna Charta, which they exacted from King John, and which we are inclined to consider the first great step in the establishment of political equality was, in reality, no different from the republic of nobles in their own land, for, in each case, the mass of the people were little better off than before, both being left in a condition of practical serfdom. And the Hungarian might almost with equal truth say, that he is no more domineering over the non-Magyars in eastern Hungary than is the German minority over the Czechs in Bohemia, and the Poles in Gallicia. Whatever may have been the cause, the fact remains that the Irishman at home has never been able to attain any higher degree of political equality than the Pole or Hungarian, yet the Irish descendants of the immigration of fifty years ago have absolutely amalgamated with us, and now conform to the highest type of American citizenship.

The final amalgamation of the Slav and Hun with our native stock is a foregone conclusion, but what the final effect will be depends largely upon the time taken to complete the alloy. Were it possible to so regulate the numbers of the new arrivals that they would never be in excess of the number of their children attending our public schools, the problem would easily adjust itself, for then we should always have more real Americans in the making than we have non-Americans in reality. A study of the history of the Hun and Slav, and a careful analysis of their respective national characteristics, seem to warrant the conclusion that they are both amenable to the ways of western progress, and that we have more to fear from their great numbers than we have from any undesirable qualities inherent in themselves.

And now we come to consider the other type of immigrant which is making itself so strongly felt in our land and which, if we are to judge by the history of other nations, will continue to be an unsolved and vexatious problem long after the Pole and the Hun and Italian are forgotten. The Jew has been a source of worry and discomfort to every nation in which he has ever settled in *any numbers,* unless we except our own. *Whether this is his own fault, or the fault of the people among whom he has cast his lot, is entirely beside the question. The point to be determined is, whether he will, or will not, in time, lose his racial identity and mix with the general population around him.* Is there anything to warrant the conclusion that he has at last found his haven in this country, and being left free to practise his religion without persecution, will become one of us in every sense of the word, except in the matter of religious belief, which is, after all, a matter of no great importance so far as citizenship is concerned. Let us answer the question in the particular instance by ascertaining how it has been solved, in the aggregate, during times already past, and then considering whether there are any essential differences in the conditions of the past and present. The first historical account of anti-semitism occurs in the book of Esther, third chapter and eighth verse—"And Haman said unto King Ahasuerus, there is a certain people scattered abroad and dispersed among the people of all the provinces of thy kingdom; and their laws are diverse from those of every people, neither keep they the King's laws: therefore it is not for the King's profit to suffer them." We all know the sequel to this speech, and how the contemplated massacre and expulsion was obviated by the wiles of the beautiful Esther. The story of this attempted expulsion of a whole race of people, almost at the dawn of history, would have no particular interest for us now had it not been the forerunner, so to speak, of like movements repeated with almost dreary monotony throughout all the centuries since. That anti-semitism is not a modern movement, having its essential cause in the crucifixion of Christ, but was, on the contrary, a well-defined policy of many nations long before the question of christianity arose as a complicating factor to confound the real issue, is a fact attested to by the Jewish historians themselves. We learn from Josephus that there were considerable Jewish colonies in all the eastern towns and among the various Greek possessions. They lived an exclusive life, mingling but little with the people, and having their own customs and laws which they refused to abandon at any price; although at utter variance with those of the Greeks about them, the authorities were continually called upon to settle disputes arising between the Jews and the people among whom they settled. Thus, in the year 14 B.C., the Ephesians requested that the right of citizenship be taken from the Jews if they would not consent to join in the worship of Diana. Nicolas, of Damascus, pled the cause of the Jews and they won the suit. Now, among all the nations of

antiquity the citizen was bound to be of the same religion as his city, but the profession of this religion called for very slight obligations so far as *belief* was concerned. In matters of faith, the Greek colonies were not at all exacting. It was this very eclecticism which the Jews seemed to hate and made him break with the world about him. The result was that he almost always asked that he be granted *special privileges*, and almost invariably got them. At the same time he was very careful to insist upon having his common rights, so the result was that he was almost universally hated throughout all the great cities, and was constantly compelled to seek a renewal of his privileges. Very much the same story is repeated in the Byzantine Empire, in Ostrogothic Italy, in Frankish and Burgundian Gaul and in Visigothic Spain. In all these countries the Jew was at first admitted without prejudice, and received on the grounds of political and social equality. In all these countries he subsequently became the object of hatred and persecution.

During the middle ages, when the Jew was truly a wanderer upon the face of the earth, and he scarcely knew which way to turn, he found safe haven in the Kingdom of Poland: in fact, for one hundred years after the charter of King Boleslas in 1264, the Jews had the privilege of mixing freely with the Polish population, and even after the modification of the charter they were never wholly cut off from this privilege. Although Poland never actually persecuted them, and for a long period of time really treated them on an equality with her own people, they have never, as a body, taken any interest in any of the great political and national questions with which she has been so continuously agitated. The German colonist, settled long after the Jew, has lost every trace of his nationality but his name. The Stuarts and O'Rourke's, who sought refuge in the republic from a hostile government, have become as ingrained in the Polish community as the Pole himself, but the Jew is still a stranger.

In France, the Jews enjoyed equal privileges until long after Christianity became an active issue. In Spain they were first admitted on equal terms. The same in England. In all these countries they finally became disagreeable to the mass of the people and restrictive legislation was directed against them. As late as 1879 Germany experienced an active anti-semitic movement. When the cause of the modern anti-Jewish feeling is analyzed, it seems to have about the same basis that it had before the time of Christ. In both cases it has been at bottom essentially a question of manners. The Jew, as a class, is different from the people among whom he has settled, and he has insisted that he be given certain special privileges which serve to emphasize the difference rather than obliterate it. In other words, he is inherently clannish. Wherever this clannishness has been forgotten and he has laid aside, or kept in the background, the customs and mannerisms which mark him as a peculiar person, he has been a welcome addition to the

land of his adoption. However, he has refused to do this except in individual instances. As a class, he has, as a matter of principle, refused to intermarry with those of other religions.

This raises the question, How can a people amalgamate and fit into the general populace when they refuse to take the one step absolutely essential to complete amalgamation? Protestants of all denominations can intermarry and still maintain their standing in their respective churches. By the exercise of a few essentially trivial formalities, protestant and catholic can intermarry and both remain good protestant and good catholic, but let the Jew marry the Gentile and the Jew is at once branded by his co-religionists as a bad Jew.

Those of his race who have conformed to the apostolic injunction, when in Rome to do as the Romans do, have always been a credit to the land of their adoption. But the tendency to adaptation has, so far, been developed only on a small scale. There does not seem to be a general movement of sufficient momentum to encourage the belief that the Jew, forgetting his race and remembering only the essential principles of his religion, will finally arrive at the goal of complete racial amalgamation. True, there is a marked tendency among the adherents of reformed Judaism in the United States to bury the antiquated customs of the past and to become real Americans, but this reformed Judaism hardly has time to make itself felt before it is dealt a killing blow by the mere force of numbers in the opposite ranks. In other words, the old ideas from the ghettos of Europe are imported so rapidly that the new has but a poor chance to gain sufficient adherents to keep pace with, and finally outstrip, the old superstitions. And this thought brings us to the final conclusion of the whole matter, and that is, whatever the race of people from which the immigrant comes, the final result is not to be feared so long as he does not come in overwhelming numbers. If he trickles in slowly we shall take care of him. Let him be what he will when he comes, the amalgamation will finally be complete. On the other hand, if we continue to let him come in what is practically unlimited numbers, we can not take care of him. He will take care of us. We shall lose our inherited Anglo-Saxon ideals, and instead of a perfect amalgamation, we shall confront the danger of a complete racial substitution.

THE CONSERVATION OF THE FOOD SUPPLY

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THE maintenance of the food supply is the basal problem of civilization. Before commerce or manufactures or mining can be carried on—before science or art or religion can flourish—man must be fed.

Hitherto, the people of the United States, thinly scattered over a country of vast extent and seemingly exhaustless fertility, have scarcely realized that there is such a thing as a food problem, but more and more frequently of late there are heard warnings of the danger of an inadequate food supply for our future millions and of the resultant peril to our democracy through the fostering of caste and class distinctions. That the problem is a serious one, even if it be not so immediately imminent as some would have us believe, admits of no reasonable doubt.

Now the problem of food supply is in essence a problem of energy supply. Food yields the energy which operates the bodily mechanism and upon the regularity and sufficiency of this energy supply depends absolutely all human endeavor. To produce those carriers of energy which we call foods is the chief function of the farmer. By means of the green leaves of his crops he entraps the energy of the sunlight and stores it up in the starches, fats and proteins of his wheat, corn, etc., to be liberated again in the body when these are used as food. The farmer as a food producer is the first link in the chain of human activities—the agent by whose labors the boundless stream of solar radiation is utilized for man's service—and the density of population which a country can support from its own resources is practically limited by the amount of solar energy which the farmer can recover in food products.

Clearly then in preparing to meet the future food problem the primary thing is to see to it that the farmer is taught how by means of tillage, fertilization, seed selection, crop rotation, and all the arts of good farming to accumulate as much as possible of the solar energy in his yearly crops. The proposition is sufficiently obvious and already commands popular support.

There is, however, another less evident aspect of the question. In order to feed the teeming millions of the future, it will not only be necessary to fix as much of the solar radiation as possible in the form of crops, but also to utilize the energy which the latter contain with the maximum of efficiency. When our population reaches half a billion, there will be little margin for waste.

Now in view of our absolute dependence on solar radiation, it is a rather startling fact that but the smaller part of the energy stored up in the farmer's crops is directly available for man's use. Of that of the wheat crop, for example, fully sixty per cent. is contained in the straw and another 10 per cent. is rejected in the process of milling as bran and other by-products. In other words, only about 30 per cent. of the energy stored in an acre of wheat is directly available for human nutrition. Much the same thing is true of most other food crops, while the grasses and clovers, so important in all systems of agriculture, are, of course, entirely unavailable as food for man. Hitherto, our enormous surplus of food products has served to obscure the significance of this fundamental fact. Not only have we been able to export vast quantities of breadstuffs to less fortunate lands, but we have used other millions of bushels of edible products, especially corn, as food for domestic animals. America has been a country of cheap animal food—meat, eggs, milk, butter, cheese, etc.—and we have been fond of drawing the comparison between the abundant meat supply of our working classes and its comparative scarcity in the diet of the European laborer and, rightly or wrongly, have attributed much of the greater industrial efficiency of our workmen to this difference in diet.

But we are rapidly approaching an economic limit to the production of meat from edible grains. Such a conversion is an exceedingly wasteful process. Of the solar energy stored up in a bushel of corn, less than 3 per cent. is recovered in the edible portion of the carcass of the steer to which it is fed, while even in pork production this percentage scarcely rises to more than 16, and in milk production to about 18, and similar losses are observed in all branches of animal production. In other words, the stockman who feeds his animals on grain is expending energy available for human use as fuel for his animal machines for the sake of recovering a small fraction of it in higher priced and more palatable products, a process which can hardly fail to remind one of the reputed origin of roast pig. So long as our food supply was vastly in excess of our needs, such practises were doubtless economically justifiable. To the solitary hunter in the primeval forest it was a matter of comparative indifference whether he made his camp fire of underbrush or of the best grade of timber, but with lumber at its present price, the mill owner can afford only sawdust and refuse to feed his fires. In the past, speaking broadly, our meat production has consisted to a large extent in the exploitation of our food resources. There has been a choice between producing bread *or* meat, and the improvements in stock husbandry have been largely in the direction of more profitable exploitation. In the near future, we shall have to reverse this attitude and study the conservation of the food supply. Not much longer can we continue to take the children's bread and cast it to the brutes. If our

abundant meat supply is to be maintained, it must be in some other way. With such a density of population as we may reasonably expect, it will no longer be a question of producing bread *or* meat, but of producing bread *and* meat. All the edible products which the farmers' acres can yield will be needed for human consumption and the function of the stock feeder in a permanent system of agriculture will be to utilize those inedible products in which so large a share of the solar energy is held and to render at least a portion of the latter available for human use. Meat and other animal products will be produced, not as luxuries for the tables of the rich, but as a means of conserving energy for human use, both directly through the food thus rescued from waste and indirectly by setting free edible plant products for man's use. The stock feeding of the future will be a very different matter from the simple grazing of cattle in summer or the lavish feeding of corn in winter. It will be a highly artificial process, dealing with feeding stuffs unfamiliar to the fathers and seeking to utilize to the utmost the energy of every available by-product. It will call for a degree and a kind of knowledge and skill far exceeding that which has sufficed in the past.

Until within a comparatively few years, but little direct study has been devoted to these fundamental considerations, especially in the United States. While institutions for agricultural research have flourished, they have either concerned themselves with the more obvious problem of increasing crop production or else, in response to the demands of stockmen, have devoted their energies largely to seeking more efficient ways of converting corn into meat. In this latter respect, they have aided in exploiting rather than in conserving food resources, and it has been difficult to secure public interest or public funds for fundamental investigation looking toward the conservation of the food supply of the future.

More than a purely scientific interest, therefore, attaches to studies of the principles governing the utilization of the stored-up energy of feeding stuffs, particularly of by-product feeds, such as have been made during the past ten or twelve years by German investigators, particularly by Kellner at the Moeckern Experiment Station, and as are now being prosecuted by the Institute of Animal Nutrition of the Pennsylvania State College in cooperation with the Bureau of Animal Industry of the United States Department of Agriculture.

Such a study is far from being a simple matter. Essentially, of course, its method must consist in feeding the products under investigation to animals and ascertaining what proportion of their energy can be thus saved. The difficulty lies in the determination of the latter point. This must be accomplished with an accuracy and a degree of detail unattainable in the ordinary feeding experiment if the conclu-

sions are to pass beyond the empirical stage and lead to the establishment of general principles. For this purpose Kellner has used a form of the so-called Pettenkofer respiration apparatus, first devised many years ago by Professor v. Pettenkofer in Munich, while the Pennsylvania institution employs an instrument known as the respiration calorimeter, first devised by the late Professor W. O. Atwater for investigations in human nutrition and which has been enlarged and modified to adapt it for experiments upon domestic animals.

The central feature of both apparatuses consists of an air-tight chamber through which a measured current of pure air passes and within which the animal stands in a comfortable stall, where it can be fed and watered at will. The total energy contained in the feed of the animal is ascertained by determining the amount of heat which a sample of it produces when completely burned, while the energy escaping in the visible excreta is measured in the same way. Furthermore, by analyzing samples of the air-current before and after its passage through the chamber containing the animal the gaseous waste products given off by the latter are determined.

Finally, energy escapes from the animal in the form of heat. In the German experiments the amount of heat produced by the animal is virtually computed from the amount and kind of materials oxidized in the body. This may also be done in the experiments with the respiration calorimeter, but in addition this apparatus is provided with appliances for the direct determination of the heat given off, it being taken up by a current of cold water circulating through copper pipes and its amount measured with the aid of sensitive thermometers. In this way the total income and outgo of the animal can be compared, the difference showing how much of the energy of the food has been stored up as meat or fat, while a comparison of the observed with the computed heat production serves as a check on the accuracy of the experiments.

The method is not unlike that employed in locomotive testing plants like, *e. g.*, that of the Pennsylvania Railroad at Altoona. Just as in the latter, the heat value of the fuel is measured, so in the experiments upon the animal the heat value of the feed, which is the fuel of the animal body, is determined. The losses in the visible excreta of the animal may be compared to unburned coal dropping through the grate, while the gaseous excreta correspond to the flue gases. A large amount of heat is given off in both cases, and the final balance of income and outgo makes it possible to trace exactly the use which the locomotive or the animal makes of the energy supplied to it.

The material or ration to be tested is fed for some three or four weeks with the greatest regularity. During the latter portion of this time, after the effect of the ration has become fully established, the animal spends from two to five days in the respiration apparatus or the

CHEMICAL ELEMENTS AND ENERGY OF INCOME AND OUTGO PER DAY

	Water		Nitrogen		Carbon		Organic Hydrogen		Energy	
	Income Grams	Outgo Grams	Income Grams	Outgo Grams	Income Grams	Outgo Grams	Income Grams	Outgo Grams	Income Calories	Outgo Calories
Consumed										
3,000 grams Timothy Hay	175	—	34.5	—	1,213.2	—	183.1	—	11,691.5	—
300 grams Wheat Bran	318	—	8.1	—	117.0	—	18.0	—	1,180.4	—
900 grams Corn Meal			13.0	—	377.3	—	51.7	—	3,323.9	—
900 grams Linseed Meal			49.5	—	384.1	—	54.5	—	3,913.8	—
10,180 grams Water	10,180	—	—	—	—	—	—	—	—	—
150.6 grams Hydrogen Oxidized	1,355	—	—	—	—	—	—	150.6	—	—
Excreted										
7,756 grams Feces	—	6,198	—	31.3	—	699.9	—	93.5	—	6,855.6
5,360 grams Urine	—	3,846	—	69.0	—	100.5	—	17.7	—	1,017.7
22 grams Hair and Brushings	—	—	—	1.6	—	9.4	—	1.3	—	103 8
102 grams Methan	—	—	—	—	—	76.2	—	25.4	—	1,359.8
3,563 grams Water Vapor	—	3,563	—	—	—	—	—	—	—	—
3,831 grams Carbon Dioxid	—	—	—	—	—	1,044.7	—	—	—	—
Heat Produced	—	—	—	—	—	—	—	—	—	9,338.5
Gain by Animal										
19 grams Body Protein	—	—	—	3.2	—	10.1	—	1.4	—	109.4
145 grams Body Fat	—	—	—	—	—	110.8	—	17.4	—	1,375.6
Loss by Animal										
1,579 grams Water	1,579	—	—	—	—	—	—	—	—	—
Error	—	—	—	—	—	—	—	—	50.8	—
	13,607	13,607	105.1	105.1	2,051.6	2.051.6	307.3	307.3	20,160.4	20,160.4

454 Grams = 1 Pound.

calorimeter under the constant observation night and day of three or four skilled men. Its intake of food and energy, the losses in the excreta, the volume, composition and temperature of the air passing through the apparatus and in the case of the respiration calorimeter especially the temperature of the water used to take up the heat produced are matters of continuous record. A single "run" with the latter apparatus involves the recording of nearly 7,000 observations, while fully 25 samples of various sorts are taken whose subsequent analysis in the chemical laboratories involves the making of some 150 determinations.

From the results of these hundreds of weighings, records and analyses there is finally worked out a complete balance of income and outgo.[1] Comparisons of these balances on different amounts and kinds of feed, with different animals, and under varying conditions, permit exact conclusions to be drawn regarding the nutritive effects of the rations consumed.

The investigations in progress relate to three different aspects of the general problem: First, how do different feeding stuffs compare with each other as to their content of energy and the proportion of it which is available to the animal? Second, what is the relative efficiency of different types of animals as converters of waste energy into human food? Third, how do the various conditions under which animals may be kept affect their efficiency in this respect? To the extent to which it becomes possible to answer these questions for the different species of farm animals we shall possess the scientific basis for a rational system of conserving to the utmost for man's use the energy which the studies of the chemist, the physicist, the botanist, the agronomist and the soil expert have taught the farmer how to accumulate in his crops. The investigations are, therefore, in reality a study of the conservation of the food supply, a problem even more fundamentally important than the conservation of our mines, forests or water powers, and one which vitally concerns the welfare not of the farmer alone but of the whole people.

[1] On page 500 is an example of such a balance sheet.

THE MORAL INFLUENCE OF A UNIVERSITY PENSION SYSTEM

By Dr. HENRY S. PRITCHETT

THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING

WHILE a college or university can not divest itself of a humane duty towards an old or worn-out teacher, it does not follow that every college is under an obligation to establish at once a system of retiring allowances. The obligation for a service performed is one thing; the question of taking on general obligations for services to be performed is quite another. It is fair, however, to say that it is the clear duty of a college at our present stage of civilization to reckon among its obligations those to old and worn-out servants and to deal with these obligations in full view of all other duties. Hitherto colleges have in the main admitted no such duty. The educational corporation has generally acknowledged no obligation to the individual when his services were no longer wanted. This attitude is no longer possible. No corporation under our social and industrial order can brush aside this humane duty. Every such organization must, as best it may, do its duty both to the public and to the individual. For this reason, therefore, no college is justified in turning out without some provision an old and faithful teacher who has long served it. It still does not follow that such an institution is in a position to establish a permanent and definite system of pensions.

The questions, what form of pension system is wise and just, and what effect the establishment of a pension system will have upon the professional and moral qualities of teachers, and what effect the establishment of such a pension system will have upon the college itself, still remain to be answered. These questions are part of a much larger one with which society is to-day engaged. Is it for the interest of society as well as for the interest of the individual that some definite provision for old age and disability be made? If so, under what conditions should such pensions be conferred and from what source shall they be provided? Should the beneficiary bear at least a part of the burden of a pension or should it be paid by the agency, whether it be corporate or governmental, which the pensioner serves? These are questions with which all modern organizations—state, business corporation or social organization—are confronted. The college or university, as one of these organizations, must also seek to answer these questions in its own way and to the extent of its responsibility.

The literature which has appeared in recent years concerning pen-

sions is large. In this country the most valuable contribution to the subject has been the Report of the Massachusetts Old Age Pension Commission, a report due in large measure to the energy and careful work of its chairman.

Pensions, as we discus them to-day, are characteristic of modern civilization. This is necessarily so. A pension system can not be valued unless it promises security, and it is only within recent history that institutions and governments have attained to any great degree of security. In the ancient world pensions are hardly met with except in the bounties paid to discharged soldiers. In the Middle Ages the church, the only stable institution, fixed no age limit for its servants, but relieved their old age by coadjutors and assistants rather than by retirement.

The modern pension systems appeared in the nineteenth century and have shown rapid growth. Their extension to all orders of society has been a feature of the opening decade of the twentieth century. This result is due to two facts: first, to our quickened sense of humanity; secondly, to the clearer appreciation that such humanity means more effective service and an improved condition of society. Minor factors have also helped to quicken the attention of the more thoughtful nations to the need of support for old age. The work of modern society is done under increased pressure and under more nervous conditions. At the same time that these changes have taken place improved public hygiene has lengthened our years beyond the average of the last century. Men's activity is exhausted at an earlier date in many callings, while at the same time improved conditions of health prolong their lives. The period in which men require help has, therefore, been extended.

The movement for a general system of pensions to aged poor, to be paid by the community, was first proposed in England in the eighteenth century. The first comprehensive plan, however, to be enacted into a national law was that adopted by the German legislation of 1891. This was followed by Danish legislation in the same year; and at the present time, in addition to these countries, France, all the Australian states, and New Zealand have old-age pension systems, while Belgium and several of the cantons of Switzerland maintain a voluntary insurance against old age. In 1898 England enacted in Parliament the most far-reaching of all old-age pension acts.

The United States government has hitherto lagged behind other nations in the investigation and study of the civil pension for its old servants. This is no doubt due in part to the prejudice against all pensions engendered by the history of the bounties bestowed by the government upon the survivors of the Civil War and their families. The payments on these pensions aggregated in 1910, forty-five years after the close of the Civil War, the enormous total of $160,000,000.

The history of this pension fund has been perhaps the greatest scandal which has fastened upon our government. This enormous payment represents not devotion to the patriots of the Civil War, but political truckling in its smallest and most objectionable form. With this lesson before them the people of the United States have hesitated to deal at all with the question of pensions for civil servants.

Notwithstanding the unwillingness of the national government to deal with the question of civil service pensions such pensions are being widely extended amongst the large business corporations and railroads. The New York Central Railroad, the Pennsylvania Railroad, the United States Steel Corporation, and many other railroad, banking and industrial corporations have established systems of pensions for their officers and employees. An interesting type of such a system has recently been authorized for the Boston and Maine Railroad by the legislature of Massachusetts. In addition, several states of the union, the last of which is Wisconsin, have inaugurated pension systems for public school teachers, maintained in considerable part by deductions from the salary of the individual.

Before the establishment of the Carnegie Foundation, pension systems for teachers, quite limited in their provisions, were in operation in the University of California, Columbia University, Cornell University, Harvard University, McGill University and Yale University. Pension systems have since been instituted in Haverford College and for those teachers connected with Teachers College at Columbia University who do not come within the rules of the foundation. In most of these colleges the entire pension was to be paid by the institution. In some of them—as, for instance, at Cornell—the pension was to be paid in part from an endowment fund and in part from the payments of the professors.

The various pension systems thus briefly alluded to as now being in operation may be divided into two general types, the non-contributory and the contributory, and the latter type must be subdivided into two subtypes—that in which the contribution of the prospective pensioner is voluntary and that in which the contribution is compulsory. It goes without saying that the variations under these types and subtypes are endless. For example, in the compulsory contributive type contributions may be required from others than the pensioner himself. Thus, the German old-age pension system regards three parties as participating—the imperial government, the employer and the employee. The last two contribute equal amounts. In the year 1907 the contributions were as follows:

Imperial government	M49,600,620
Employers	89,321,600
Employees	89,321,600
Total	M228,243,820

In other words, the total expense on account of old age pensions in Germany for that year amounted approximately to $57,000,000, of which the state paid something over $12,000,000—an interesting contrast to the enormous expenditure of the United States upon war pensions in the same year, the difference arising in the main from the fact that one expenditure was made under a carefully thought-out and carefully planned system, the other under an arrangement largely the result of accident modified by political considerations.

The relative wisdom of these different forms of pension systems has been the subject of sharp discussion during the past fifteen years. Out of this discussion one or two general principles appear to have been settled. The investigators of pension systems agree that the pension should be paid under definite and specific conditions, not as a matter of chance or of preference. A second conclusion to which practically all publicists have come is that the system under which a part of the pension is paid by the employing agency, but in which entrance to the pension system is a voluntary act, is a failure. Not that such a pension system will not accomplish good for many of those who enter it, but the very person it is instituted to relieve will not be affected by it. Such a system will, as a rule, fail either to relieve or to educate those lacking thrift, the very class most likely to need aid in old age. The experience of the past seems to show that one might as well expect all government civil servants to take out life insurance policies as to enter into such a plan for the relief of old age.

The discusion of pension systems at the present date, therefore, has practically settled down to the consideration of two systems: either one in which the contribution is compulsory upon all the prospective pensioners, or one in which the entire cost is borne by the regulating authority. It seems likely that in the future the development of pension systems by corporations or by governments will be along one of these lines, and this notwithstanding the fact that serious objections have been made and continue to be made to both plans.

If contributions are exacted from all, the contributors acquire rights which in some cases prove embarrassing to the administrators of the fund, if that administration be a government or a corporation. For example, great difficulty was found in dismissing certain dishonest police officers in New York City, because by their contributions to the pension fund of the force they claimed a vested right in their office. This, of course, is an extreme case.

It has also been shown by experience that in a contributory pension system the employees will sooner or later make the following demands, which it is difficult for the employer to resist, and yet which greatly increase the cost of the pension system: (1) that if the employee resigns or is discharged his contributions shall be returned to him, with interest;

(2) that if the employee is disabled permanently through illness or accident before he arrives at the retiring age, he shall receive a proportional pension; (3) that if the employee dies before arriving at the age of retirement, his estate shall receive his contributions, with interest; (4) that if the employee retires, but dies before the total of his pension receipt equals the total of his contributions, his estate shall receive the difference, with interest.

The difficulties of maintaining a non-contributory pension system for a very large class of beneficiaries are also serious. No such system has been in existence long enough to afford much useful experience, and the estimates of experts are so affected by the lengthening of life in civilized countries, by the unforeseeable growth of the class to come under the pension system, and by that curious tendency for the average age in a community or a class to rise as the community or the class grows, that such a pension fund is liable to sudden and unexpected strains unless there are provisions for its increase from some large source—for example, government appropriations, or a supporting fund.

The difficulties of either of these systems are not insuperable. The doctrine of law which protects the contributor to a pension fund protects him only against what the law regards as arbitrary action and is difficult chiefly because it requires the management of the fund to proceed in all cases with a regard for legal precedent which laymen are apt to regard as excessive and which at times interferes with efficient management. If, however, justice and the necessary procedure of the law are adhered to, the compulsory contributory feature need not cause embarrassment.

The objection to the non-contributory scheme may be also obviated by economy, by a careful study of the laws of vital statistics of the class affected, by the general observance of just and fair management with the funds at the disposal of the managing agency and by the cooperation of beneficiaries themselves.

The practical question which faces those who are considering pension systems is, therefore, the relative advantages of the compulsory contributive type and of the non-contributory type. Both of these are immensely preferable to the unfair and inhumane system which they are intended to displace. Secretary MacVeagh has most clearly pointed out that, except with employers of peculiar hardness, all governments and institutions conduct their operations really on an imperfect pension system. The secretary writes in his report for 1909: "The service is blocked in many instances by the unwillingness of the officials in charge to throw out of place worthy men and women who have given the best of their lives to the work of the government. So that, in a very imperfect and wholly unsatisfactory manner, a pension system is, and long has been, in operation." Every college officer appreciates the fact that the colleges are also maintaining, in this imperfect sense, a pension

system, but one qualified at every step by favoritism or partiality. One who has occasion to visit many colleges of the country will be astonished at times by two methods of procedure in this matter, diametrically opposite, and yet entirely to be reconciled with the methods under which our colleges are governed. He will be astonished in the first place at the inhumanity which will turn out an old teacher after long service with no means of support. He will be astonished in the second place at many institutions by the presence in the faculty of a considerable proportion of teachers who have long outlived their usefulness and who are practically pensioned by their retention in service. It is not one of the smallest of the disadvantages of this form of pensioning that the presence of the aged and the infirm often arouses in the minds of shallow and impatient men a disregard for the really superior qualities which many of those in advanced years possess. There are always those who believe under such circumstances that all evils can be remedied by a sweeping edict which often tears down more than it builds up.

The most serious objections brought against either the contributory or the non-contributory form of pension are two. Those who make the objections fear that pensions from an outside source may undermine the sturdy virtue of independence, and in the second place that the granting of such pensions and the security which may come from their anticipation will produce a decay of the fundamental virtue of thrift. To these moral arguments may be added the economic contention that pensions lower wages.

While there are certain differences between systems of pensions intended for working men and those intended for teachers, it nevertheless remains true that all these objections may be urged against a system of pensions for teachers with as much reason as against a system of pensions for working men. Human nature in teachers and in working men is in no sense different, and if these be sound objections in one case they are doubtless sound objections in the other.

The first of these objections seems to me to rest in large measure upon a false ground. A man can be independent and yet not insist upon paying himself for everything that he receives. In the complex organization of modern society no individual in any class of society pays for everything which he receives. The wealthy boy at college is a pensioner in very much the same way that the poor boy is. John Hampden lost nothing of his feeling of independence by partaking of the bounty of William of Waynefleet. Nor did Milton or Charles Darwin experience any impairment of their sturdy qualities of spirit from having been educated through the generosity of the Lady Margaret. That is a singular, and probably a narrow, man who has not partaken of the benevolence of others. The whole effect and outcome of that participation depends upon the spirit in which the benevolence is tendered

and the spirit in which it is accepted. In a well-conducted pension system the administrators have in the main to come to a judicial determination as to whether a specific individual has complied with the conditions or not. If he has so complied, the awarding of the pension is very much like the payment of a salary.

Most persons who have thought concerning this matter feel much more strongly the argument that pensions discourage thrift than they do the objection that they cause a loss of independence. Thrift is a fundamental human virtue. Hard to build up in races and individuals, it is easy to break down in both. The true course in the training of human individuals and in the training of human communities would seem to be not to set thrift in opposition to the moral results achieved by a pension system, but to realize that the growth of thrift is analogous to the growth of all spiritual and moral faculties. It is just because the habit of thrift is so difficult to acquire and to retain that pensions are not antagonistic to it. The security given by a pension system is really the acquisition of a certain equity which will result in benefit to those who participate in it. Such a consideration, if rightly used, can be made to minister to the idea of thrift, not to break it down.

In fact, the whole theory that possible destitution in old age is the prime cause of thrift seems to need revision. Hope, not fear, is the great moving power in humanity. To save so that the income will be a decent support seems to many, and these often in highly respectable callings, so hopeless a task that to undertake it unaided appears foolish, but with a living assured in old age there is an incentive to save in order that additional pleasures or greater advantages for others might then be possible. It must, however, be admitted that the contributory type of pension lends itself more directly to the upbuilding of such a spirit than the non-contributory type. From the larger economic as well as from the larger moral standpoint the plan of a contributory pension seems to promise least danger to society and the greatest result. I am inclined to believe from such evidence as the pension systems which now exist can furnish that a justly regulated compulsory contributory pension system, on the whole, promises most both for the individual and for the social organization.

The economic argument that pensions depress wages is too vague to furnish any sound basis of objection. From the economic point of view the argument has weight, but in the actual administration of business so many factors influence wages that a pension, even if it exercised its influence on this side, must have a relatively small effect. It may be true that in certain cases the existence of a pension system may be used to persuade a man to enter a given calling and to undertake a given line of work for a smaller recompense on the ground that he is to receive a pension in the future. This argument certainly may apply to teachers

as to all other classes of men who offer themselves for employment, but the experience of the foundation up to the present time indicates that this factor is relatively negligible. Since the inauguration of the Carnegie Foundation salaries of professors in colleges have steadily risen. The existence of a pension system in a college, while it may now and then be used to induce a man to undertake a particular work for a smaller salary, is nevertheless so small a factor that it does not count materially in the presence of other large factors in the matter of salaries.

The justification for a pension system, however, can not be found in its negative qualities, or in its comparative freedom from injurious results to the individual and to society. It must not only prevent suffering and inefficiency, but it must also raise the quality of service amongst those to whom it applies.

That a rightly administered pension system does this is already fairly proved. Particularly is this true where the labor of those under the system is mental labor, and still more when that labor is partly of a creative nature and upon subjects of no immediate concern to the individual. Anxiety and apprehension are the most deadly foes not only to mental exertion, but to the higher intellectual qualities of imagination and invention. A man may indeed put forth unusual intellectual effort for a few years in facing the problems of individual and family support, but to assume that concentration on such problems during a series of years, accompanied by distressing uncertainty as to his future, will help the quality of his teaching or his research is against human experience. Profitable study and the cheerful performance of severe tasks are aided by serenity, not perplexity of mind. Especially is this true of the fruitful period of middle life. If it be true that we are still so uncivilized that a prospect of serene and helpful old age is demoralizing to men of high intellectual training, then the cure for this situation does not lie in making old age uncertain and insecure, but in the gradual education of men to a better ideal of life. The experience of the Carnegie Foundation, short as it is, carries a strong argument in favor of the betterment in the work of the college teacher which comes from a knowledge that his old age is protected. Outside of all direct results to society arising from pensions, the argument drawn from humane and religious reasons probably will always appeal most strongly. The system of employment which uses the services of a highly trained individual at meager pay up to the point where he is no longer effective and then takes no concern for his welfare and for those dependent on him has a remnant of barbarism about it which arouses a protest in the conscience of civilized man. Our religious and our humane ideals demand that some effort should be made to solve this problem.

In all that has been said the systems of pensions under consideration have been those which arose gradually. For example, the system adopted by the German government came about after years of agitation and discussion. Pensions in the German universities began with the contributions of the professors themselves, and only after a long period of time and a long discussion of the economic and moral questions involved was the burden of pensions shifted entirely from the shoulders of the teacher to the purse of the government. The system of pensions supported by the Carnegie Foundation in the accepted institutions, in marked contrast to these, is one founded out of hand by the generosity of one man. It has inaugurated a series of pensions which are paid practically through the colleges, for the individual teacher has no occasion to know the Carnegie Foundation at all. He deals simply with his college.

Even when one admits the general good results flowing from a well-administered system of pensions, either upon the contributory plan or upon the non-contributory plan, there still remains the question, what is the moral effect of such a pension system as that which has been conducted during the last five years with the funds held by the trustees of the Carnegie Foundation?

The good side of this retiring allowance system is very easy to see. The letters which come from old teachers grown gray in the service of a modest college, speaking of the relief of mind and spirit which has come to them through this protection tell a story so full of human interest and of human happiness that there is no answer to such a recital. There is little danger that a pension will demoralize a man who up to sixty-five or seventy years of age has given his life to the hard and unselfish work of a teacher. Perhaps no feature of the Carnegie pensions has been more appreciated than that provision under which half of the pension of the teacher is paid to his widow. The meaning of this feature of the pension system was vividly stated in a letter which came to the foundation from the widow of an old college teacher in the middle west. Her husband had taught for forty years in a small college. He had accepted a year before a modest pension, and at his death the half of this pension, amounting only to fifty dollars a month, had been allotted to his widow. In acknowledging the receipt of the first payment she wrote, "Perhaps you can not understand how much it means to me to receive what some would consider so modest a sum, but with my little house in this small town this payment means the difference between dependence and independence." It is this which the teacher values most in his old age—independence for himself and for the wife who may survive him. The result of the Carnegie Foundation pensions in this direction has been all that one could wish.

No less evident has been the good effect of the foundation pensions

upon the colleges themselves. Where the foundation has enabled a college to retire in a dignified and just way teachers who had worn out their usefulness and where it has enabled colleges to substitute in their place younger men of fresh and alert spirit, the result has been to quicken and vivify the whole intellectual life of the college. Here again is a result whose benefit no one can question.

On the other hand, there is another side which can not be lost sight of. The presence of the altruistic spirit amongst college teachers is strong, but perhaps no stronger than amongst other men. As in every calling a large number of those in the profession of the teacher are drawn to it by bread and butter motives. The offering of a pension can not fail in some cases to minister to the selfish side of human nature. There will always be certain individuals who, when they find themselves in possession of a given advantage, whether that take the form of a benefit in the hand or one to be acquired in the future, will trade upon the possession or the prospect of that benefit. There will be under such an arrangement a certain number of teachers who will count the years and the days until the coming of the minimum age which enables them to resign the duties which they now perform in a perfunctory and routine way. There are still other men facing responsibilities and difficulties in administrative places or in teaching who would gladly use the way of the pension to escape from the perplexities and responsibilities of their positions. Every president considers his own case an exceptional one. He is prepared to prove to the foundation, even when he is turned out of office by the trustees for alleged incompetence, that he is entitled to a pension on the ground of extraordinarily meritorious service. Every teacher, too, thinks his own situation is unique and that he is entitled to consideration of a special sort by reason of his particular and unusual service. All this arises out of the qualities of human nature. On the whole, the number of those whose selfishness is touched by such a benefit is small, as small perhaps as one ought to expect, and in the long run much of this will disappear as the teachers themselves become accustomed to a system of pensions. In time teachers will realize that it is to their own interest and in the direction of their own happiness to continue work as long as they are really fit and able to serve. The late William T. Harris always insisted that a college professor was at his best between the ages of sixty-five and seventy-five, and he strongly urged the trustees of the Carnegie Foundation at the inception of the trust not to make the minimum retiring age lower than seventy. Mr. Harris's argument was a partial one, but it had truth in it. There are many teachers who are at their ripest and at their best between sixty-five and seventy-five and such men ought, of course, to remain in their profession. In the long run it will be found that they will do so, although for a few years the

idea of the pension will induce some men to surrender work at an earlier age than they ought. It is impossible to offer to men an advantage such as that which flows from a pension system of any sort without arousing in some minds the question—How can I get the most out of it? But the number of such individuals amongst college teachers is small and will become smaller as the standards of college life rise.

Nor can one shut one's eyes to the fact that the colleges themselves may, by reason of the pensions of the foundation, neglect their own duty in taking care of their old teachers. The officers of the foundation have done all in their power to make it clear to the colleges that the funds at their command and likely in the future to be at their command could care for only a limited number of colleges. Nevertheless, in spite of this effort, it has been tacitly assumed by many colleges, and generally by those of the lowest standards in scholarship, that any obligation on their part to care for their old teachers had vanished with the inauguration of the foundation. This phase of the situation is also, I believe, a temporary one.

One other feature of the Carnegie Foundation pensions has aroused criticism. This is the plan of a centralized pension fund and the fact that this agency deals in its publications with general educational questions which touch directly university interests and educational policies.

The dread of a centralized agency in any field of social activity is one which depends largely on the point of view of the individual. The idea that such an agency as the Carnegie Foundation will exert arbitrary pressure upon those colleges which choose to accept its pensions seems to me improbable. Such agencies, like universities themselves, are in the end molded by public opinion. There is, however, no method by which this can be proved to one who sees in the existence of such an agency unfortunate influences upon the colleges and universities. The two opinions result from differences in the point of view, not from differences in intellectual honesty and sincerity, and such differences of view only time and experience can bring together.

It seems to me, however, that the argument that a central educational agency may exert arbitrary and unwise influence over the universities may be very fairly compared with a similar arraignment of the universities themselves which, by a somewhat singular coincidence, was put forward at a meeting of teachers simultaneously with the one just alluded to.

This complaint came from the secondary school men. They argued that the universities are outside corporations having little sympathy and knowledge of secondary school work and yet not only ready to exert over the high school an arbitrary power, but actually in a number of cases exerting this power to the harm of the secondary schools. These secondary school teachers protested most strongly against the domination of any such outside irresponsible agency.

That there is a measure of truth in this complaint no one who knows the educational situation will deny. And yet I fancy that no man is ready to advocate the abolition of universities in order to preserve the rights of the secondary schools. The real lesson, on the other hand, is that of a wise cooperation. No agency in civilized society, not even a university, can have absolute independence. What such an institution can have is freedom, to be gained however by due observance of its right relations to all other agencies in the social order. In a democracy the power of public opinion, as fast as public opinion is educated, will bring about such cooperation. The remedy for possible danger to the rights of the individual or of the single institution does not seem to lie in reducing all agencies to ineffectiveness, but rather in the general education of the whole people to an appreciation of the observance of the law. In the last analysis an educated public opinion will regulate both the relations of centralized educational agencies to the universities and the relations of the universities to the secondary schools. Meantime, no man in either form of organization will object to sincere and discriminating criticism. It is such criticism which educates public opinion.

Notwithstanding the incidental difficulties, therefore, which arise in the administration of any system of pensions, I believe that the advantages which have resulted from the conferring of pensions have far outweighed the disadvantages and that, furthermore, the advantages on the whole seem likely to become stronger with time, while the disadvantages seem likely to diminish. The value of a pension system depends not only on the intelligence and conscience of those who administer it, but on the spirit and morals of those who are to benefit by it, and the dangers of a pension system lie mainly in those universal dangers which come from human weakness and human selfishness.

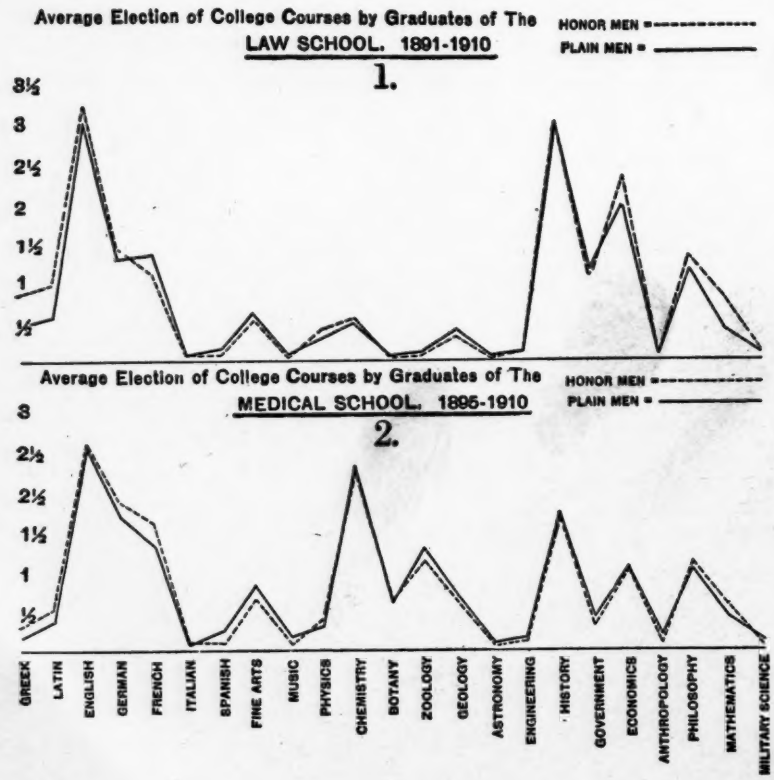
It is, to my thinking, a fair question whether the college pensions ought not, like other pensions, to carry a contributory feature. No one can be more sensible than I of the tremendous demands made upon the meager salaries of the American college teachers, and yet notwithstanding this, it is impossible to remove the college teacher from those social and moral obligations which affect all men. The experience of the world seems to point strongly to the conclusion that on the whole a contributory form of pension is likely to be most just and least harmful.

THE PROGRESS OF SCIENCE

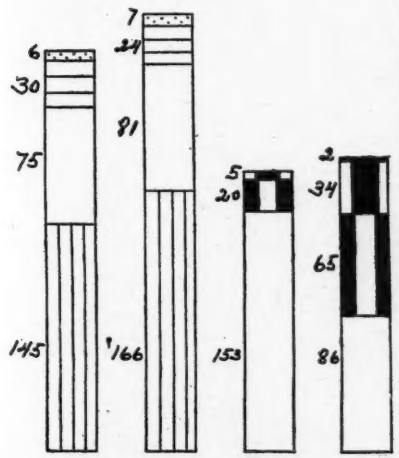
COLLEGE STUDIES AND PROFESSIONAL TRAINING

IN *The Educational Review* for October, President Lowell, of Harvard University, gives some interesting statistics in regard to studies pursued in college and success in the work of the professional school. In a general way he finds that students who enter Harvard College without conditions do well in their college studies and that students who do well in college also do well in the schools of law and medicine, whereas their standing in the professional schools is not dependent on the kinds of studies pursued in college.

The diagram shows the average election of college courses by graduates of the law and medical schools, the broken lines representing the men who graduated from the professional schools with honors and the plain lines those who did not. It is apparent that the future law students took more work in history, government and economics, and the future medical students more work in the natural sciences. But the law students who in college elected more work than the average in history and political science did not do better than the others, and the medical students who elected more work than the average in



the sciences did not excel the others. On the contrary, it appears that of the 23 men who took ten or more courses in science, only 39 per cent. graduated *cum laude* from the medical school, whereas of 48 men who took less than three courses 61 per cent. graduated *cum laude*. In general, it was the case that students who elected six or more courses in any one of the four groups into which the studies at Harvard are now divided did equally well in the professional school whatever the group



The two columns on the left represent the students in the medical school who did not and who did receive honors in accordance with the subjects pursued in college. The two columns on the right represent those who did not and those who did receive honors in the medical school in accordance with their standing in college.

in which the larger share of work was done. The relations for the medical school are shown on the chart. Of 311 students who elected six or more courses in the languages in college, 145 graduated without and 166 with honors from the medical school. Of those who took six or more courses in the natural sciences, 75 graduated without and 81 with honors. Within the limits of probable error, the relations are the same for the smaller groups in political science and in philosophy and mathematics.

The two columns on the right side of the diagram show the relations between high standing in college and success in the work of the medical course. Of the 239 men who received no honors in college 36 per cent. were given honors in the medical school; of the 85 with a *cum laude* in college, 76 per cent.; of the 39 with *magna cum laude*, 87 per cent.; and the two who received *summa cum laude* received honors in the medical school.

President Lowell's theories are certainly supported by these statistics. He holds that men should be incited to obtain high grades in college and that the college course should be purely cultural without reference to the student's work in after life. He has argued that the college course should make all students equally well prepared to enter any professional school and that the entrance requirements of each professional school should be such that they are met by all students having completed a college course. Every one will of course agree that it is a good thing for students to do well in their college work, even though it may be doubted how much is gained by trying to lead students to compete with one another for honors, as President Lowell advocates. It is, however, a legitimate incentive to good work to make it known that students who do well in college, are likely also to succeed in the professional school and in after life.

The fact that students do equally well in the medical school, whatever the studies they pursued in college, is a stronger argument for cultural studies than any theory. It is not quite convincing, as it may be argued that the courses in the natural sciences given to students at Harvard are proved by these statistics not to be the best training for the future medical student. We know that students who do well in one subject in college are likely to do well in others. This was put on a quantitative basis by Dr. Clark Wissler in a doctor's thesis from the psychological department of Columbia University,

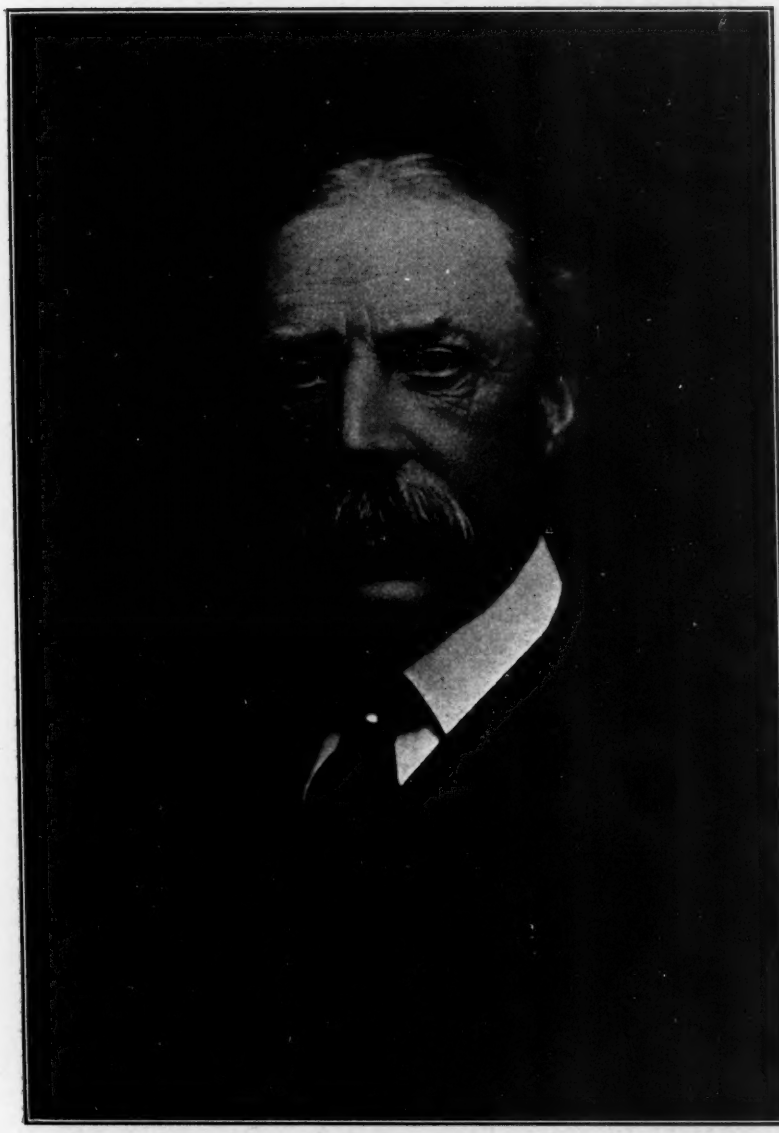
which showed that the correlation was about 0.60. The student who did well in Latin not only was likely to do well in other studies, but was as likely to do as well in mathematics or in gymnasium work as in French. Ability and hard work lead to success rather than special aptitudes or previous training. Apart from manual skill, the student can learn in four years about as much as he is able to remember, and consequently students at the end of the Harvard medical course can pass their examinations about as well whatever were their studies four to eight years before.

This does not, however, mean that a student might not have passed these examinations equally well if he had begun his medical work two years sooner and begun to practise medicine two years earlier, or that he would not have been a better prepared physician if he had left the college at the end of the sophomore year and spent six years in the work of the medical school. The real difficulty in the way of a prolonged college course in its bearing on future professional work is that the student begins too late. This is an economic danger, as only the well-to-do can enter the professions, and it is psychologically unfortunate, as by the time a man has begun his real work in life, he has passed the period when he is best able to learn how to carry it forward and most likely to have new ideas.

THE PORTSMOUTH MEETING OF THE BRITISH ASSOCIATION

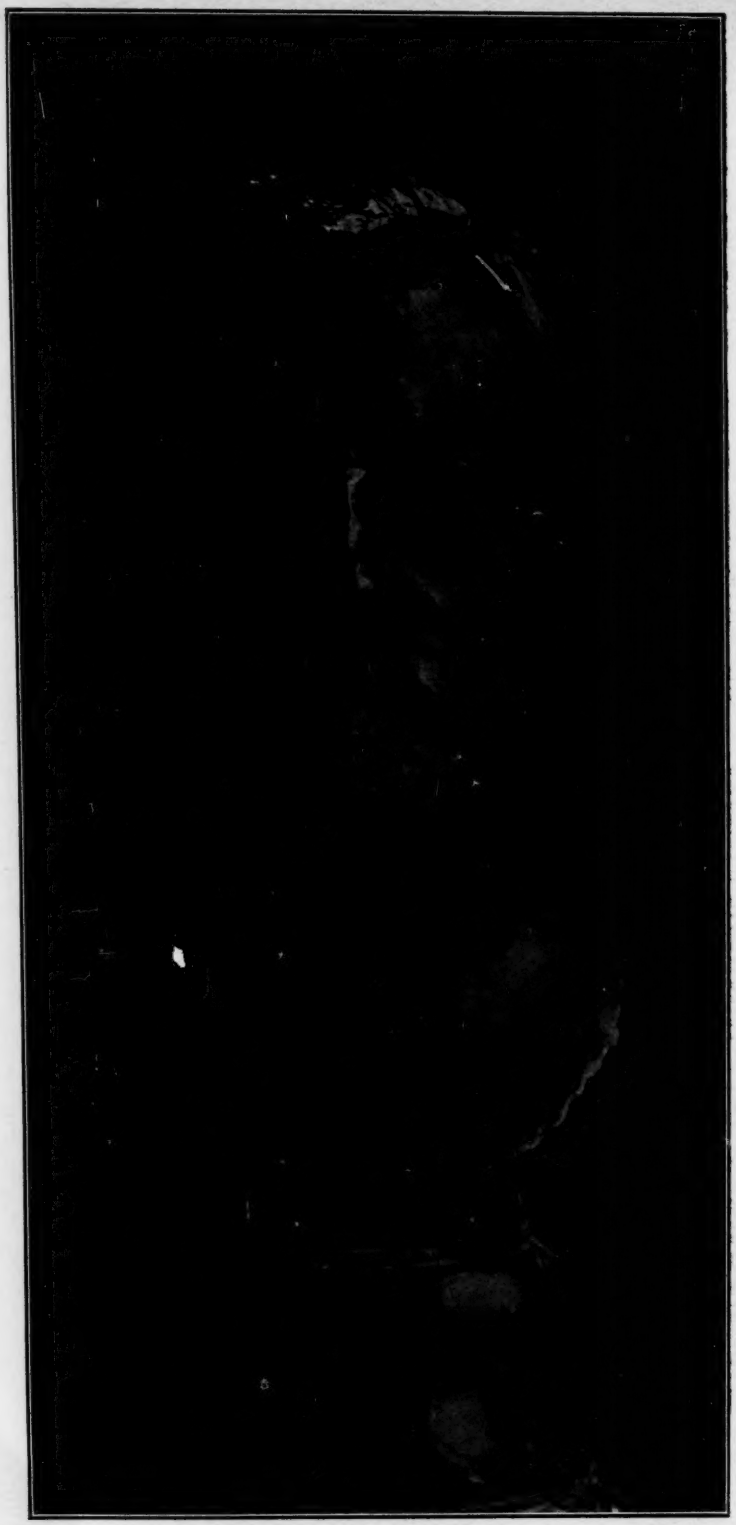
THE meeting of the British Association at Portsmouth appears to have maintained the high traditions of its eighty years of scientific service. The attendance of about 1,400 was smaller than usual, but this depends on the number of local associates who join for the meeting. Details are not at hand for Portsmouth, but at one of the larger recent meetings there were in attendance 885 members, a large part of whom were not engaged in scientific work, and in addition to these there were registered 1,384 local associates and 873 ladies. This indicates a striking difference between the meetings of the British and American associations, which has become even more emphasized in recent years. At the approaching meeting of the American Association and its affiliated societies at Washington, there will probably be about 2,500 members in attendance who will be almost exclusively scientific men. They go to attend the meetings of the special societies having very technical programs; the people of the city will know very little about the meetings and will not even attend the addresses and sessions which might be of interest to them.

The constitution of the British Association states that one of its principal objects is "to obtain a more general attention to the objects of science." The constitution of the American Association contains a similar statement. Both associations have concerned themselves with the diffusion as well as with the advancement of science, and it must be admitted that the British Association has in this direction been the more successful. It accomplishes more for the city in which it meets, and the city in turn provides social functions such as are unknown in this country. At Portsmouth there were two dukes ready to entertain the members at their castles and a bishop to preach for them on Sunday. The mayor offered both a garden party and an evening reception, and there were all sorts of social entertainments. There were excursions to the Isle of Wight and to the New Forest, and the members were taken on a battleship to witness an attack by torpedo-boat destroyers and submarines. The association in turn arranged a number of public lectures and general addresses, and these were fully reported in the daily press. Thus the London *Times* published the address of the president, Sir William Ramsay, and large parts of other addresses, together with full accounts of the proceedings. It printed in advance an elaborate forecast of the meeting and afterwards an



DR. E. A. SCHÄFER,

Professor of Physiology in the University of Edinburgh, President of the British Association for the Advancement of Science.



Bust of Pasteur.

Presented by the Pasteur Institute, Paris, to the Rockefeller Institute for Medical Research, New York.

PROFESSOR ED. SUESS,

Emeritus Professor of Geology in the University of Vienna.

extended report, devoting many pages to it. Nothing of that kind happens in America. The general organization of society here accounts for the absence of social functions which can perhaps be well spared, but it seems to be unfortunate that a democratic society does not take an active interest in the scientific work which has made possible its existence and on which it depends for its extension and permanence.

At Portsmouth, Professor E. A. Schäfer, the eminent physiologist of the University of Edinburgh, was elected to preside over the meeting to be held next year at Dundee. The association will meet the following year in Birmingham, and in 1914 or 1915 a visit is planned to Australia. The British Association has in recent years met in South Africa and in Canada, and in this way fulfils its national and imperial functions better than the American Association, which has never met further west than Denver. It may be hoped that our association will in 1915 meet on the Pacific coast and at Hawaii. It might be possible to arrange that those members who were able should proceed to Australasia to attend the meetings there, while British and Australian men of science might join our association at Hawaii and in California, with an opportunity to visit the San Francisco Exposition, which should aim to surpass the St. Louis Exposition in its scientific congresses.

A HANDBOOK OF UNIVERSITIES

Minerva, which for twenty years has been an invaluable annual for university men, has issued as a supplement a volume containing details of the organization of universities and colleges throughout the world. It is to be followed by a second volume with similar material in regard to libraries, museums, observatories, etc. A vast amount of information is packed into 623 pages, printed in type almost too small to be legible. Like the annual issue of *Minerva*, it is edited with unusual accuracy, but, as is likely to be the case, the material appears to be the more satisfactory, the less the first-hand knowledge of the reader. Thus the only lectureship referred to under American universities is the "Sethman (intended for Silliman) lecturer at Yale." The following account of our fraternities would not give a clear or correct impression to foreigners: "In the larger colleges and in the universities most students are members of one or more 'fraternities.' The members live in the college, usually together in a chapter house. The most important is the Phi Beta Kappa Fraternity, founded in 1776." It is not true that Columbia University was in 1890 "completely reorganized on the model of the German universities." There is no reason to include the Cooper Union and to exclude the West Point Military Academy. But it seems captious to point out minor inaccuracies in a book covering such a wide field. The publishers and editors should rather be congratulated on the production of a book which could not be accomplished outside Germany. The frontispiece, here reproduced, is a portrait of Dr. Ed. Suess, professor emeritus of geology of the University of Vienna, who has just celebrated his eightieth birthday and has retired from the presidency of the Vienna Academy of Sciences.

SCIENTIFIC ITEMS

WE record with regret the deaths of Professor Edward Lee Hancock, professor of applied mechanics in the Worcester Polytechnic Institute; of the Rev. Mariam Balcells, professor of mathematics at Boston College, previously director of the department of solar physics at the Observatorio del Ebro, and of Mr. Edward Whymper, known for his explorations among the Alps and in the Andes.

DR. C. WILLARD HAYES, chief geologist of the U. S. Geological Survey, has retired to engage in technological work in Mexico.—At the meeting of the corporation of Yale University on September 18, Sir William Osler, regius professor of medicine at Oxford, was appointed Silliman lecturer for 1912, and Dr. Joseph P. Iddings, until 1908 professor of petrology in the University of Chicago, and now engaged in geological research, was appointed lecturer for 1913.

OWING to the epidemic of cholera, the various international congresses, geographical, agricultural and tuberculosis, will not meet in Rome this autumn. They have been postponed until the spring of 1912, the exact dates not yet being determined.—By invitation of the trustees of the New York Public Library the autumn meeting of the National Academy of Sciences will be held in its new building, beginning on November 21.

AMONG the public bequests made by Mr. George M. Pullman was that of $1,200,000 for founding and endowing the Pullman Free School of Manual Training at Pullman, Ill. This fund has increased to more than $2,500,000. The first step toward founding the school was the purchase, in 1908, of a campus of forty acres within the limits of the town of Pullman at a cost of $100,000. Mr. Laenas Gifford Weld, until recently professor of mathematics and dean of the faculty of liberal arts in the Iowa State University, was appointed principal in May and entered upon his new duties September 1. He will visit the leading technical and trade schools in this country and in Europe before the preparation of definite plans is undertaken.